

ANGLO-CHINESE JUNIOR COLLEGE
DEPARTMENT OF CHEMISTRY
Preliminary Examination

CHEMISTRY
Higher 1

8873/01

Paper 1 Multiple Choice

29 August 2018
1 hour

Additional Materials: Multiple Choice Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

Write your name, index number and tutorial class on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A, B, C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

The use of an approved scientific calculator is expected, where appropriate.

This document consists of **12** printed pages.

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ANGLO-CHINESE JUNIOR COLLEGE
Department of Chemistry

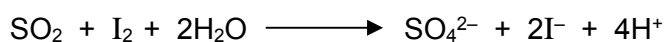
[Turn over

- 1 *Use of the Data Booklet is relevant to this question.*

Which of the following statements is **incorrect**?

- A 35.5 g of chlorine gas contains 6.0×10^{23} chlorine atoms.
- B 24 dm^3 of hydrogen gas at $20 \text{ }^\circ\text{C}$ and 1 atm contains 1.2×10^{24} hydrogen atoms.
- C 500 cm^3 of 1 mol dm^{-3} aqueous magnesium nitrate contains 3.0×10^{23} nitrate ions.
- D 4 g of helium gas contains 6.0×10^{23} helium atoms.
- 2 Wines often contain a small amount of sulfur dioxide that is added as a preservative. The sulfur dioxide content of a wine is found by the following method:

A 50 cm^3 sample of white wine reacted with 40.0 cm^3 of 0.01 mol dm^{-3} aqueous iodine. The sulfur dioxide in the wine is oxidised to sulfate, SO_4^{2-} , in the process.



The unreacted iodine requires exactly 23.60 cm^3 of 0.02 mol dm^{-3} sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$, for complete reaction.

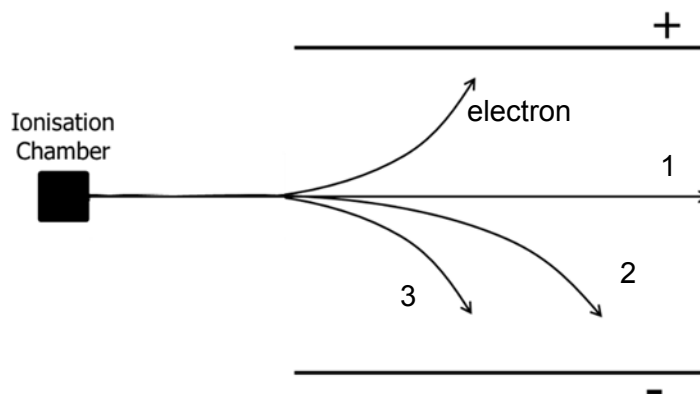
What is the concentration of sulfur dioxide, in mol dm^{-3} , in the wine?

- A 1.64×10^{-4}
- B 3.28×10^{-3}
- C 4.72×10^{-3}
- D 9.44×10^{-3}

- 3 Use of the Data Booklet is relevant to this question.

${}_{94}^{243}\text{Pu}$ can undergo natural radioactive decay, where one of its electrons enters the nucleus to change a proton into a neutron, to form a new element **M**.

When **M** is put in an ionisation chamber, it emits a high energy α -particle (which is a ${}^4\text{He}$ nucleus).

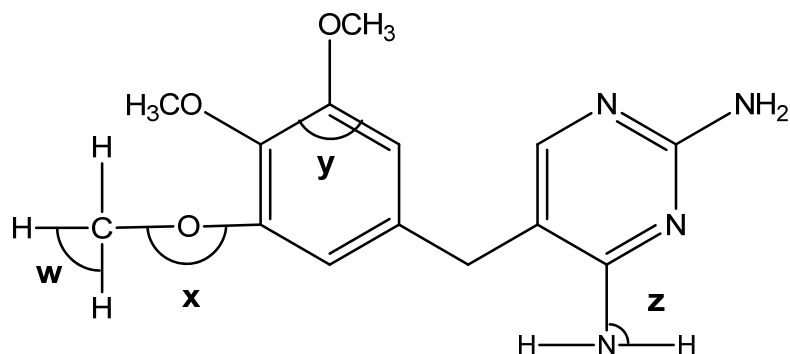


What is the identity of the element **M** and the path of the emitted α -particle in an electric field?

	chemical symbol of M	path of α -particles
A	${}_{93}^{243}\text{M}$	2
B	${}_{95}^{243}\text{M}$	1
C	${}_{93}^{244}\text{M}$	2
D	${}_{95}^{244}\text{M}$	3

- 4 Which of the following species has more protons than neutrons, and more electrons than protons?
- A** He^+
B CO
C OH^-
D F^-

- 5 Trimethoprim (TMP) is used for the treatment of urinary tract infections. It has the following structure:



In which sequence are the bond angles **w**, **x**, **y** and **z** quoted in decreasing order?

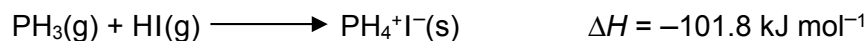
- A $y > w > z > x$
 B $x > z = y > w$
 C $y > w > x > z$
 D $x > z > y > w$
- 6 What is the reason of the difference in bond angle in the molecule of ammonia and water?
- A the number of lone electron pairs in the molecule
 B a bonding electron pair having greater repulsive force than a lone electron pair
 C a greater repulsion between the hydrogen atoms in the longer N–H bond length
 D a greater repulsion between the hydrogen atoms in the shorter O–H bond length

- 7 When 1.50 g of propan-1,2,3-triol, $C_3H_8O_3$, ($M_r = 92.0$) was burnt, it was found that 100 g of water was heated from 25 °C to 67 °C. This process was found to have an efficiency of 80%.

What is the magnitude for the enthalpy change of combustion of propan-1,2,3-triol in kJ mol^{-1} ?

The specific heat capacity of water is $4.2 \text{ J g}^{-1} \text{ K}^{-1}$.

- A 866
 B 879
 C 1350
 D 1370
- 8 Phosphine reacts with hydrogen iodide to form phosphonium iodide in the reaction shown.



Given that ΔH_f for $\text{PH}_3 = +5.4 \text{ kJ mol}^{-1}$, and ΔH_f for $\text{HI} = +26.5 \text{ kJ mol}^{-1}$, what is the standard enthalpy change of formation of phosphonium iodide?

- A $-133.7 \text{ kJ mol}^{-1}$
 B $-69.9 \text{ kJ mol}^{-1}$
 C $+133.7 \text{ kJ mol}^{-1}$
 D $+69.9 \text{ kJ mol}^{-1}$
- 9 The table shows the charge and radius of each of six ions.

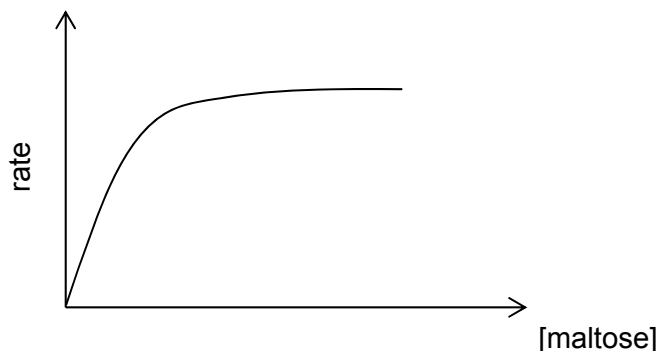
Ion	J^+	L^+	M^{2+}	X^-	Y^-	Z^{2-}
radius / nm	0.14	0.18	0.15	0.14	0.18	0.15

The ionic solids **JX**, **LY** and **MZ** are of the same lattice type.

What is the correct order of their lattice energies, placing the least exothermic first?

- A **JX, LY, MZ**
 B **JX, MZ, LY**
 C **LY, JX, MZ**
 D **LY, MZ, JX**

- 10 The graph shows the results of an investigation of the initial rate of hydrolysis of maltose by the enzyme amylase. In the experiments, the initial concentration of maltose is varied but that of amylase is kept constant.



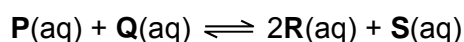
Which of the following **cannot** be deduced from the above information?

- 1 When [maltose] is low, the rate is first order with respect to maltose.
 - 2 When [maltose] is high, the rate is zero order with respect to maltose.
 - 3 When [maltose] is high, the rate is zero order with respect to amylase.
- A** 2 only **B** 3 only **C** 1, 2 and 3 **D** 1 and 2 only
- 11 The decomposition $2\text{N}_2\text{O}_5 \longrightarrow 4\text{NO}_2 + \text{O}_2$ is first order with respect to N_2O_5 .
- In an experiment, 0.10 mol of pure N_2O_5 was in an evacuated flask. It was found that there was 0.025 mol of N_2O_5 left after x minutes.
- Which of the following statement is true?
- A** The half-life of N_2O_5 is $\frac{x}{2}$ minutes.
 - B** The time taken for 0.20 mol of N_2O_5 to reduce to 0.10 mol is x minutes.
 - C** The half-life is not constant for the decomposition of 0.40 mol of N_2O_5 .
 - D** There was 0.0125 mol of N_2O_5 left after $2x$ minutes.
- 12 A catalytic converter is part of the exhaust system of modern cars. Which reaction does **not** occur in a catalytic converter?
- A** $2\text{C}_x\text{H}_y + (4x + y)\text{NO} \longrightarrow 2x\text{CO}_2 + y\text{H}_2\text{O} + (2x + \frac{y}{2})\text{N}_2$
 - B** $\text{C}_x\text{H}_y + (x + \frac{y}{4})\text{O}_2 \longrightarrow x\text{CO}_2 + \frac{y}{2}\text{H}_2\text{O}$
 - C** $2\text{CO} + 2\text{NO} \longrightarrow 2\text{CO}_2 + \text{N}_2$
 - D** $\text{CO}_2 + \text{NO} \longrightarrow \text{CO} + \text{NO}_2$

13 Which of the following statements is true about dynamic equilibrium?

- A All of the reactants are used up.
- B The reactants have stopped reacting.
- C The concentrations of the reactants and products are equal.
- D The rate of the forward reaction is equal to the rate of the backward reaction.

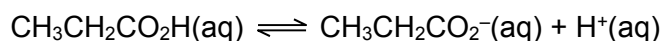
14 An equilibrium can be represented by the following equation:



The total volume of the reaction mixture is 1 dm³ and the equilibrium concentration of **Q** is 0.8 mol dm⁻³.

What will the new equilibrium concentration of **Q** be if 0.4 moles of **Q** is completely dissolved in the mixture?

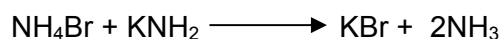
- A 1.2 mol dm⁻³
 - B between 0.8 mol dm⁻³ and 1.2 mol dm⁻³
 - C 0.8 mol dm⁻³
 - D between 0.4 mol dm⁻³ and 0.8 mol dm⁻³
- 15 Propanoic acid is used in baked products to inhibit the growth of mould. Propanoic acid, when dissolved in water, dissociates according to this equation:



Which of the following statement about propanoic acid is correct?

- A Adding NaOH will have no effect on the amount of propanoic acid that is dissociated.
- B 0.1 mol dm⁻³ of propanoic acid will have a pH of 1.
- C The Brønsted-Lowry conjugate base of propanoic acid is the CH₃CH₂CO₂⁻ ion.
- D Increasing the concentration of propanoic acid will increase the *K_c* value.

- 16 Under appropriate conditions, NH_4Br and KNH_2 react as follows:



How is the reaction best classified?

- A disproportionation
B acid-base
C redox
D condensation
- 17 The ionic product of water, K_w at 10°C is $2.93 \times 10^{-15} \text{ mol}^2 \text{ dm}^{-6}$.
What is the pH of a solution containing 0.02 mol dm^{-3} of strong base $\text{Ba}(\text{OH})_2$ at 10°C ?
A 12.6 B 12.9 C 13.1 D 13.3
- 18 Given that a $0.500 \text{ mol dm}^{-3}$ of HNO_2 solution has a K_a value of 7.1×10^{-4} , what is the percentage of **undissociated** HNO_2 molecules?
$$\text{HNO}_2 \rightleftharpoons \text{H}^+ + \text{NO}_2^-$$

A 1.88 % B 3.77 % C 96.2 % D 98.1 %
- 19 Which of the following oxide is unlikely to react with aqueous sodium hydroxide?
A magnesium oxide
B aluminium oxide
C phosphorus pentoxide
D sulfur trioxide
- 20 Which of the following elements form an oxide with a giant covalent structure and a chloride which is readily hydrolysed?
A magnesium
B sodium
C phosphorus
D silicon

21 Which statements are true about the elements in Group 1 of the Periodic Table?

- 1 Their ionic radii increase down the group.
- 2 They are reducing agents.
- 3 Their electronegativities decrease down the group.

A 2 and 3 only **B** 1 and 3 only **C** 1, 2 and 3 **D** 1 only

22 Which statements about Group 17 elements and the hydrogen halides are correct?

- 1 Thermal stability of hydrogen halides decreases down the group.
- 2 Oxidising power of the halogens decreases down the group.
- 3 Iodine is insoluble in organic solvents.

A 2 and 3 only **B** 1 and 2 only **C** 1, 2 and 3 **D** 1 only

23 Which compound reacts with its oxidised product (an oxidation which involves no loss of carbon) to give a sweet-smelling liquid?

- A** propanal
B propanoic acid
C propanone
D propan-1-ol

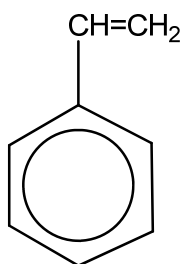
24 Which property does the compound produced by the addition of liquid bromine to propene have?

- 1 It can exist as a pair of cis-trans isomers.
- 2 It possesses permanent dipole-permanent dipole interactions between molecules.
- 3 It is planar.

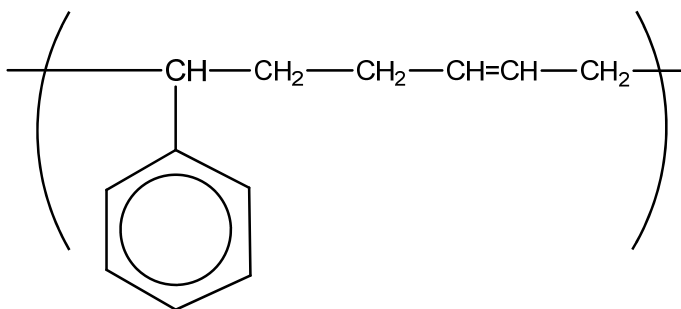
A 2 only **B** 1 and 3 only **C** 1, 2 and 3 **D** 3 only

- 25 Why does the reaction $\text{CH}_3\text{CH}_2\text{X} + \text{OH}^- \rightarrow \text{CH}_3\text{CH}_2\text{OH} + \text{X}^-$ take place more rapidly in aqueous solution when X is changed from Br to I?
- A The I⁻ ion is a stronger reactant than the Br⁻ ion.
 - B The I⁻ ion is less hydrated than the Br⁻ ion.
 - C The C–Br bond is more polar than the C–I bond.
 - D The C–Br bond is stronger than the C–I bond.
- 26 Which one of the following pairs of compounds might be made to combine together under suitable conditions to form a polyamide?
- A a mono-amine and a monocarboxylic acid
 - B a diamine and a monocarboxylic acid
 - C a diamine and a dicarboxylic acid
 - D a mono-amine and a dicarboxylic acid
- 27 Polymerisation of chloroethene gives poly(vinyl chloride) or PVC.
- How does the carbon-carbon bond in PVC compare with that of chloroethene?
- A longer and stronger
 - B longer and weaker
 - C shorter and stronger
 - D shorter and weaker

28 Which monomer co-polymerises with



to give a polymer with the repeat unit shown below?



- A $\text{H}_3\text{C}-\overset{\text{CH}_3}{\text{C}}=\text{CH}_2$
- B $\text{CH}_3-\text{CH}=\text{CH}-\text{CH}_3$
- C $\text{CH}_2=\text{CH}-\text{CH}_2-\text{CH}_3$
- D $\text{CH}_2=\text{CH}-\text{CH}=\text{CH}_2$

29 Which of the following statements are **incorrect**?

- 1 Graphene has low tensile strength.
- 2 Geckos are able to stick to walls as they form strong covalent bonds to the walls.
- 3 Catalytic converters have a honeycomb structure to maximize the surface area available for catalysis to take place.

- A 1 and 2 only B 1 and 3 only C 1, 2 and 3 D 1 only

30 What is the maximum size, in at least one dimension, of a nanomaterial?

A 1×10^{-6} m

B 1×10^{-7} m

C 1×10^{-8} m

D 1×10^{-9} m

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Section A

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

1	C	11	A	21	C
2	B	12	D	22	B
3	A	13	D	23	D
4	C	14	B	24	A
5	A	15	C	25	D
6	A	16	B	26	C
7	C	17	C	27	B
8	B	18	C	28	D
9	C	19	A	29	A
10	B	20	D	30	B

1 Use of the Data Booklet is relevant to this question.

Which of the following statements is **incorrect**?

- A** 35.5 g of chlorine gas contains 6.0×10^{23} chlorine atoms.
- B** 24 dm³ of hydrogen gas at 20 °C and 1 atm contains 1.2×10^{24} hydrogen atoms.
- C** 500 cm³ of 1 mol dm⁻³ aqueous magnesium nitrate contains 3.0×10^{23} nitrate ions.
- D** 4 g of helium gas contains 6.0×10^{23} helium atoms.

Answer: C

$$\text{A: } n(\text{Cl atoms}) = \frac{35.5}{71.0} \times 2 = 1.0 \text{ mol} \Rightarrow 6 \times 10^{23} \text{ Cl atoms}$$

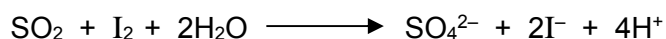
$$\text{B: } n(\text{H atoms}) = \frac{24}{24} \times 2 = 2.0 \text{ mol} \Rightarrow 2 \times 6 \times 10^{23} \text{ H atoms} = 1.2 \times 10^{24} \text{ H atoms}$$

$$\text{C: } n(\text{NO}_3^- \text{ ions}) = \frac{500}{1000} \times 1 \times 2 = 1.0 \text{ mol} \Rightarrow 6 \times 10^{23} \text{ NO}_3^- \text{ ions}$$

$$\text{D: } n(\text{He atoms}) = \frac{4}{4} = 1.0 \text{ mol} \Rightarrow 6 \times 10^{23} \text{ He atoms}$$

2 Wines often contain a small amount of sulfur dioxide that is added as a preservative. The sulfur dioxide content of a wine is found by the following method:

A 50 cm³ sample of white wine reacted with 40.0 cm³ of 0.01 mol dm⁻³ aqueous iodine. The sulfur dioxide in the wine is oxidised to sulfate, SO₄²⁻, in the process.

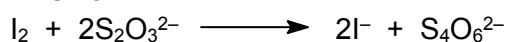


The unreacted iodine requires exactly 23.60 cm³ of 0.02 mol dm⁻³ sodium thiosulfate, Na₂S₂O₃, for complete reaction.

What is the concentration of sulfur dioxide, in mol dm⁻³, in the wine?

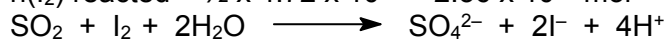
- A 1.64 x 10⁻⁴
B 3.28 x 10⁻³
 C 4.72 x 10⁻³
 D 9.44 x 10⁻³

Answer: B



$$n(\text{S}_2\text{O}_3^{2-}) \text{ reacted} = 23.60 \times 10^{-3} \times 0.02 = 4.72 \times 10^{-4} \text{ mol}$$

$$n(\text{I}_2) \text{ reacted} = \frac{1}{2} \times 4.72 \times 10^{-4} = 2.36 \times 10^{-4} \text{ mol}$$



$$\text{initial } n(\text{I}_2) = 40.0 \times 10^{-3} \times 0.01 = 4.00 \times 10^{-4} \text{ mol}$$

$$n(\text{I}_2) \text{ reacted with SO}_2 = 4.00 \times 10^{-4} - 2.36 \times 10^{-4} = 1.64 \times 10^{-4} \text{ mol}$$

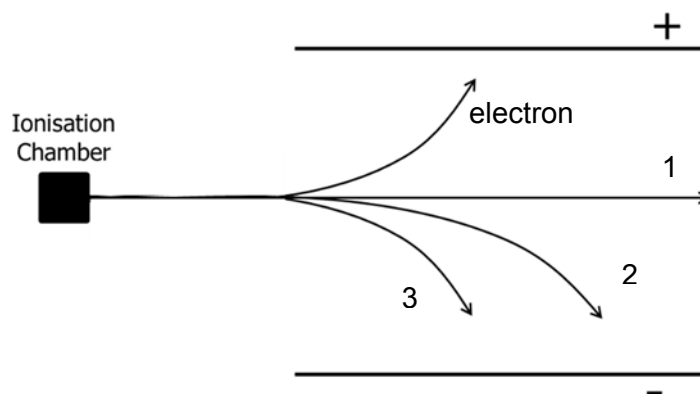
$$n(\text{SO}_2) \text{ in wine} = n(\text{I}_2) \text{ reacted} = 1.64 \times 10^{-4} \text{ mol}$$

$$[\text{SO}_2] \text{ in wine} = 1.64 \times 10^{-4} / 50 \times 10^{-3} = \underline{3.28 \times 10^{-3} \text{ mol dm}^{-3}}$$

3 Use of the Data Booklet is relevant to this question.

²⁴³₉₄Pu can undergo natural radioactive decay, where one of its electrons enters the nucleus to change a proton into a neutron, to form a new element **M**.

When **M** is put in an ionisation chamber, it emits a high energy α-particle (which is a ⁴He nucleus).



What is the identity of the element **M** and the path of the emitted α-particle in an electric field?

	Chemical symbol of M	Path of (α-particles)

A	${}^{243}_{93}\text{M}$	2
B	${}^{243}_{95}\text{M}$	1
C	${}^{244}_{93}\text{M}$	2
D	${}^{244}_{95}\text{M}$	3

Answer: A

${}^{243}_{94}\text{Pu}$ converts one proton to one neutron to produce ${}^{243}_{93}\text{M}$ as there is no net change in the nucleon number. The emitted alpha particle is the nucleus of ${}^4\text{He}$. It has a charge of +2 since there are 2 protons thus it will be deflected towards the negative plate. The charge/mass ratio of the nucleus of ${}^4\text{He}$ is smaller than that of electron (electron has negligible mass) hence angle of deflection of nucleus of ${}^4\text{He}$ is smaller.

4 Which of the following species has more protons than neutrons, and more electrons than protons?

- A He⁺
- B CO
- C OH⁻
- D F⁻

Answer: C

Species that contain more electrons than protons should be negatively-charged (anions). Hence, options A and B are incorrect.

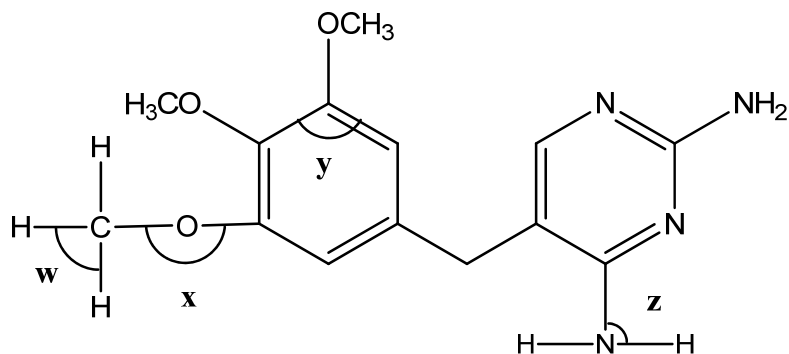
C: Total number of protons = 8 + 1 = 9

Total number of neutrons = 8 + 0 = 8

D: Total number of protons = 9

Total number of neutrons = 19 – 9 = 10

- 5 Trimethoprim (TMP) is used for the treatment of urinary tract infections. It has the following structure:



In which sequence are the bond angles **w**, **x**, **y** and **z** quoted in decreasing order?

- A** $y > w > z > x$
B $x > z = y > w$
C $y > w > x > z$
D $x > z > y > w$

Answer: A

The compression of bond angles depends on the number of lp present.

w: 109.5° (4 bp, 0 lp around sp^3 C)

x: $\ll 109.5^\circ$ (2 bp, 2 lp around O)

y: 120° (3 bp, 0 lp around sp^2 C)

z: $< 109.5^\circ$ (3 bp, 1 lp around N)

Hence, $y > w > z > x$.

- 6 What is the reason of the difference in bond angle in the molecule of ammonia and water?

- A** the number of lone electron pairs in the molecule
B a bonding electron pair having greater repulsive force than a lone electron pair
C a greater repulsion between the hydrogen atoms in the longer N–H bond length
D a greater repulsion between the hydrogen atoms in the shorter O–H bond length

Answer: A

Recall **VSEPR theory**: Electron pairs around the central atom of a molecule repel each other such that they are as far apart from each other as possible to minimise electron pair repulsion.

⇒ A **lone pair exerts a stronger repulsion than a bond pair** as a lone pair is non-bonding and thus the electron density is closer to the nucleus of the atom.

⇒ Thus, the strength of electrostatic repulsion between electron pairs decreases in the order: **lone pair–lone pair > lone pair–bond pair > bond pair–bond pair**

- 7 When 1.50 g of propan-1,2,3-triol, $C_3H_8O_3$, ($M_r = 92.0$) was burnt, it was found that 100 g of water was heated from 25 °C to 67 °C. This process was found to have an efficiency of 80%.

What is the magnitude for the enthalpy change of combustion of propan-1,2,3-triol in kJ mol^{-1} ?

The specific heat capacity of water is $4.2 \text{ J g}^{-1} \text{ K}^{-1}$.

- A 866
 B 879
 C 1350
 D 1370

Answer: C

heat energy absorbed by the calorimeter (80%) = $mc\Delta T = (100)(4.2)(67 - 25)$ =

heat energy produced by the combustion of $C_3H_8O_3$ (100%) = $\frac{100}{80}(100)(4.2)(42)$

$$n(C_3H_8O_3) \text{ burnt} = \frac{1.5}{92.0}$$

$$\begin{aligned} \text{Enthalpy change of combustion of } C_3H_8O_3 &= -\frac{(100)(100)(4.2)(42)}{(80)\left(\frac{1.5}{92}\right)} \text{ (J mol}^{-1}\text{)} \\ &= -\frac{(10000)(4.2)(42)(92)}{(1000)(80)(1.5)} \text{ (kJ mol}^{-1}\text{)} \\ &= -\frac{(10)(4.2)(42)(92)}{(80)(1.5)} \text{ (kJ mol}^{-1}\text{)} \\ &= -1350 \text{ kJ mol}^{-1} \end{aligned}$$

- 8 Phosphine reacts with hydrogen iodide to form phosphonium iodide in the reaction shown.



Given that ΔH_f for $PH_3 = +5.4 \text{ kJ mol}^{-1}$, and ΔH_f for $HI = +26.5 \text{ kJ mol}^{-1}$, what is the standard enthalpy change of formation of phosphonium iodide?

- A -133.7 kJ mol^{-1}

- B** -69.9 kJ mol⁻¹
C +133.7 kJ mol⁻¹
D +69.9 kJ mol⁻¹

Answer: B

$$\Delta H_{\text{rxn}} = \Delta H_{\text{f(products)}} - \Delta H_{\text{f(reactants)}}$$

$$-101.8 = \Delta H_{\text{f(products)}} - (+5.4 + 26.5)$$

$$\Delta H_{\text{f(products)}} = \Delta H_{\text{f(PH}_4\text{I)}} = -69.9 \text{ kJ mol}^{-1}$$

9 The table shows the charge and radius of each of six ions.

ion	J ⁺	L ⁺	M ²⁺	X ⁻	Y ⁻	Z ²⁻
radius / nm	0.14	0.18	0.15	0.14	0.18	0.15

The ionic solids JX, LY and MZ are of the same lattice type.

What is the correct order of their lattice energies, placing the least exothermic first?

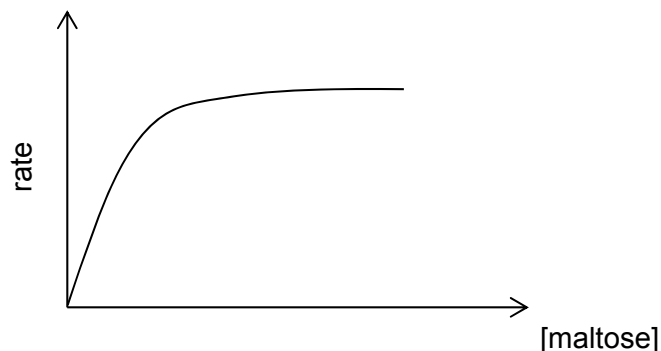
- A** JX, LY, MZ
B JX, MZ, LY
C LY, JX, MZ
D LY, MZ, JX

Answer: C

Since $\text{LE} \propto \frac{q^+q^-}{r_+ + r_-}$ and charge of ions is the dominant factor, you should expect the ionic compound formed from M²⁺ and Z²⁻ to have the most exothermic LE.

JX and LY have the same charge on the cation and anion but the lattice energy of JX is more exothermic than LY because it has a smaller ionic radius of the cation and anion

10 The graph shows the results of an investigation of the initial rate of hydrolysis of maltose by the enzyme amylase. In the experiments, the initial concentration of maltose is varied but that of amylase is kept constant.



Which of the following **cannot** be deduced from the above information?

- 1 When [maltose] is low, the rate is first order with respect to maltose.
- 2 When [maltose] is high, the rate is zero order with respect to maltose.
- 3 When [maltose] is high, the rate is zero order with respect to amylase.

A 2 only **B 3 only** C 1, 2 and 3 D 1 and 2 only

Answer: B

Option 1: is correct. When [maltose] is low, rate increases (a straight line graph passing through origin is obtained). Hence rate is first order with respect to maltose.

Option 2: is correct. When [maltose] is high, rate remains constant (horizontal straight line)

Option 3: There is insufficient information to conclude. In general, enzymes concentrate the reactant molecules (i.e. maltose in this case) by forming temporary bonds with them and thus providing an alternative pathway with lower E_a for the reactants to react. From above, when the [maltose] is high, the rate is more likely to be dependent on the [amylase] (enzyme) as amylase is now the "limiting factor"..

- 11 The decomposition $2\text{N}_2\text{O}_5 \longrightarrow 4\text{NO}_2 + \text{O}_2$ is first order with respect to N_2O_5 .

In an experiment, 0.10 mol of pure N_2O_5 was in an evacuated flask. It was found that there was 0.025 mol of N_2O_5 left after x minutes.

Which of the following statement is true?

- A** The half-life of N_2O_5 is $\frac{x}{2}$ minutes
- B The time taken for 0.20 mol of N_2O_5 to reduce to 0.10 mol is x minutes.
- C The half-life is not constant for the decomposition of 0.40 mol of N_2O_5 .
- D There was 0.0125 mol of N_2O_5 left after $2x$ minutes.

Answer: A

rate = $k[\text{N}_2\text{O}_5]$ (1st order reaction)

and time taken for $[\text{N}_2\text{O}_5]$ to decrease to $\frac{1}{4}[\text{N}_2\text{O}_5]_{\text{original}} = x$ min

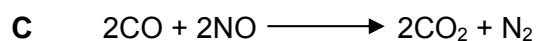
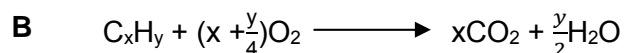
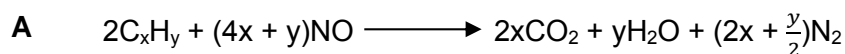
A is correct. Hence, time taken for $[\text{H}_2\text{O}_2]$ to decrease to $\frac{1}{2}[\text{N}_2\text{O}_5]_{\text{original}} = \frac{1}{2}x$ min

B is incorrect. Half-life is independent of the [reactant] for a 1st order reaction. Hence the time taken would still be $\frac{1}{2}x$ min.

C Half-life should be constant even if initial concentration of reactant is not the same.

D time taken for $[\text{N}_2\text{O}_5]$ to decrease to $\frac{1}{8}[\text{N}_2\text{O}_5]_{\text{original}}$ will be $\frac{3}{2}x$ min.

12 A catalytic converter is part of the exhaust system of modern cars. Which reaction does **not** occur in a catalytic converter?



Answer: D

In the catalytic converter, air pollutants such as carbon monoxide, unburnt hydrocarbons and nitrogen oxides are converted to non-polluting products such as carbon dioxide, water and nitrogen.

Options A, B & C – Unburnt hydrocarbons (C_xH_y) are converted to CO_2 and H_2O while NO is converted to N_2 and CO is converted to CO_2 .

Option D – Both CO and NO_2 are air pollutants and should not be formed.

13 Which of the following statements is true about dynamic equilibrium?

A All of the reactants are used up.

B The reactants have stopped reacting.

C The concentrations of the reactants and products are equal.

D The rate of the forward reaction is equal to the rate of the backward reaction.

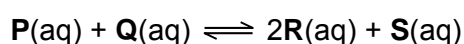
Answer: D

A False because reactants and products will exist together when dynamic equilibrium is achieved.

B False. The reactants will continue to form products and the products are also forming reactants.

C False. The concentrations of the reactants and products remain constant but are not equal to each other.

14 An equilibrium can be represented by the following equation:



The total volume of the reaction mixture is 1 dm^3 , and the equilibrium concentration of **Q** is 0.8 mol dm^{-3} .

What will the new equilibrium concentration of **Q** be if 0.4 moles of **Q** is completely dissolved in the mixture?

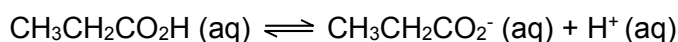
- A 1.2 mol dm⁻³
- B Between 0.8 mol dm⁻³ and 1.2 mol dm⁻³**
- C 0.8 mol dm⁻³
- D Between 0.4 mol dm⁻³ and 0.8 mol dm⁻³

Answer: B

At the point of addition, the concentration of **Q** is $0.8 + 0.4 = 1.2 \text{ mol dm}^{-3}$

However, according to LCP, some of the **Q** added will react to form the products **R** and **S**, thus removing **Q**. The amount of **Q** removed would not be more than the amount that has been added, thus the new equilibrium concentration would be between between 0.8 mol dm⁻³ and 1.2 mol dm⁻³.

- 15** Propanoic acid is used in baked products to inhibit the growth of mould. Propanoic acid, when dissolved in water, dissociates according to this equation:



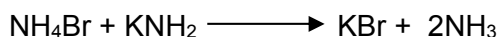
Which of the following statement about propanoic acid is correct?

- A Adding NaOH will have no effect on the amount of propanoic acid that is dissociated.
- B 0.1 mol dm⁻³ of propanoic acid will have a pH of 1.
- C The Brønsted-Lowry conjugate base of propanoic acid is the CH₃CH₂CO₂⁻ ion.**
- D Increasing the concentration of propanoic acid will increase the K_c value.

Answer: C

- A: Adding NaOH will react with H⁺ and hence shift the position of equilibrium forward.
- B: 0.1 mol dm⁻³ of propanoic acid will have a pH > 1 because propanoic acid is weak and hence $[\text{H}^+] < [\text{CH}_3\text{CH}_2\text{CO}_2\text{H}]$
- D: K_c is only affected by changes in temperature.

- 16** Under appropriate conditions, NH₄Br and KNH₂ react as follows:



How is the reaction best classified?

- A Disproportionation
- B acid-base**
- C Redox
- D condensation

Answer: B

NH₄⁺ is an acid, it donates proton to form NH₃. NH₂⁻ is a base and accepts proton to

from NH_3 .

- 17 The ionic product of water, K_w at 10°C is $2.93 \times 10^{-15} \text{ mol}^2 \text{ dm}^{-6}$.
What is the pH of a solution containing 0.02 mol dm^{-3} of strong base $\text{Ba}(\text{OH})_2$ at 10°C ?

A 12.6 B 12.9 C 13.1 D 13.3

Answer: C



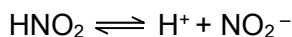
$$[\text{OH}^-] = 2 \times 0.02 = 0.04 \text{ mol dm}^{-3}$$

$$\text{pOH} = -\log [\text{OH}^-] = -\log 0.04 = 1.3979$$

$$\text{pK}_w = -\log K_w = -\log (2.93 \times 10^{-15}) = 14.533$$

$$\text{pH} = 14.533 - \text{pOH} = 14.533 - 1.3979 = 13.1$$

- 18 Given that a $0.500 \text{ mol dm}^{-3}$ of HNO_2 solution has a K_a value of 7.1×10^{-4} , what is the percentage of **undissociated** HNO_2 molecules?



A 1.88 % B 3.77 % C 96.2 % D 98.1 %

Answer: C

$$[\text{H}^+] = (7.1 \times 10^{-4} \times 0.5)^{1/2} = 0.0188 \text{ mol dm}^{-3}$$

$$\text{Percentage of undissociated } \text{HNO}_2 \text{ molecules} = 0.5 - [\text{H}^+] / [\text{HA}]$$

$$= (0.5 - 0.0188 / 0.5) \times 100\% = 96.2\%$$

- 19 Which of the following oxide is unlikely to react with aqueous sodium hydroxide?

A magnesium oxide
B aluminium oxide
C phosphorus pentoxide
D sulfur trioxide

Answer: A

MgO is basic, Al_2O_3 is amphoteric and will react with both acids and bases

P_4O_{10} and SO_3 are both acidic and will react with aq NaOH .

- 20 Which of the following elements form an oxide with a giant covalent structure and a chloride which is readily hydrolysed?

A magnesium
B sodium
C phosphorus
D silicon

Answer: D

SiO_2 is giant covalent and SiCl_4 is readily hydrolysed to form HCl.

21 Which statements are true about the elements in Group 1 of the Periodic Table?

- 1 Their ionic radii increase down the Group.
- 2 They are reducing agents.
- 3 Their electronegativities decrease down the Group.

A 2 and 3 only **B** 1 and 3 only **C** 1, 2 and 3 **D** 1 only

Answer: C

Option 1 is correct as the ionic radii increase down the group due to the increase in number of quantum shells

Option 2 is correct as they are reducing agents as they are able to be oxidised easily by losing electrons. Na forms Na^+ easily.

Option 3 is correct as you go down the group, electronegativity will decrease due to the increase in number of quantum shells, distance between protons and valence electrons increase, valence electrons are less strongly attracted to the nucleus, it is harder for electrons to be attracted.

22 Which statements about Group 17 elements and the hydrogen halides are correct?

- 1 Thermal stability of hydrogen halides decreases down the group.
- 2 Oxidising power of the halogens decreases down the group.
- 3 Iodine is insoluble in organic solvents

A 2 and 3 only **B** 1 and 2 only **C** 1, 2 and 3 **D** 1 only

Answer: B

Option 1 is correct as the H-X bond is longer and weaker. Less energy needed to break the H-X bond. Hence the thermal stability decreases down the group.

Option 2 is correct as the ability to be reduced decreases down the group. It is less easily reduced as it is less able to accept electrons. As the atomic size increases, the attraction of the nucleus for an electron also decreases.

Option 3 is incorrect as iodine forms $\text{I} \cdots \text{I}$ interactions with organic solvents hence it is soluble.

23 Which compound reacts with its oxidised product (an oxidation which involves no loss of carbon) to give a sweet-smelling liquid?

- A** propanal
- B** propanoic acid
- C** propanone
- D** propan-1-ol

Answer: D

Propan-1-ol will oxidise to form propanoic acid. The carboxylic acid will react with the alcohol to form an ester, a sweet-smelling liquid.

- 24 Which property does the compound produced by the addition of liquid bromine to propene have?
- 1 It can exist as a pair of cis-trans isomers.
 - 2 It possesses permanent dipole-permanent dipole interactions between molecules.
 - 3 It is planar.
- A** 2 only **B** 1 and 3 only **C** 1, 2 and 3 **D** 3 only

Answer: A

Option 1: Propene reacts with bromine to form 1,2-dibromopropane. Hence there is no cis-trans isomerism,

Option 2: The product 1,2-dibromopropane is a polar molecule and there are pd-pd interactions between molecules.

Option 3: 1,2-dibromopropane is tetrahedral about each carbon atom as each carbon has 4 single bonds.

- 25 Why does the reaction $\text{CH}_3\text{CH}_2\text{X} + \text{OH}^- \rightarrow \text{CH}_3\text{CH}_2\text{OH} + \text{X}^-$ take place more rapidly in aqueous solution when X is changed from Br to I?
- A** The I⁻ ion is a stronger reactant than the Br⁻ ion.
 - B** The I⁻ ion is less hydrated than the Br⁻ ion.
 - C** The C-Br bond is more polar than the C-I bond.
 - D** The C-Br bond is stronger than the C-I bond.

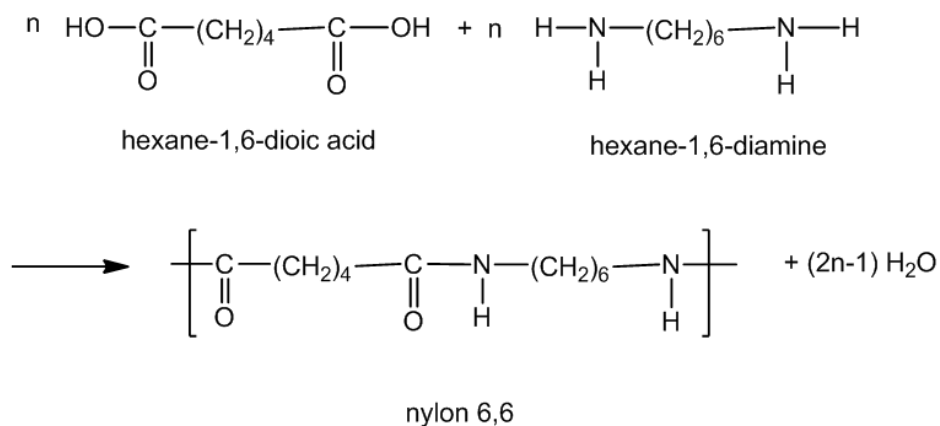
Answer: D

As the C-I bond is longer due to the smaller extent of overlap of atomic orbitals, it is weaker than the C-Br bond. Hence the C-I is weaker and more easily broken, the substitution reaction is also faster.

- 26 Which one of the following pairs of compounds might be made to combine together under suitable conditions to form a polyamide?
- A** a mono-amine and a monocarboxylic acid
 - B** a diamine and a monocarboxylic acid
 - C** a diamine and a dicarboxylic acid
 - D** a mono-amine and a dicarboxylic acid

Answer: C

Nylon 6,6 is a polyamide and is made from a diacid and a diamine.

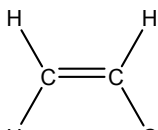


27 Polymerisation of chloroethene gives poly(vinyl chloride) or PVC.

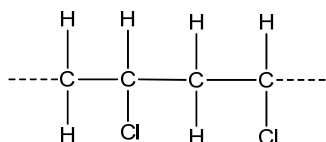
How does the carbon-carbon bond in PVC compare with that of chloroethene?

- A longer and stronger
- B longer and weaker**
- C shorter and stronger
- D shorter and weaker

Answer: B

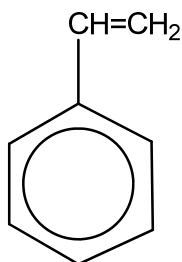


For chloroethene: $\text{H}_2\text{C}=\text{CHCl}$, C is sp^2 , C-C bonds are double bonds, C has less p character hence they are shorter and stronger.

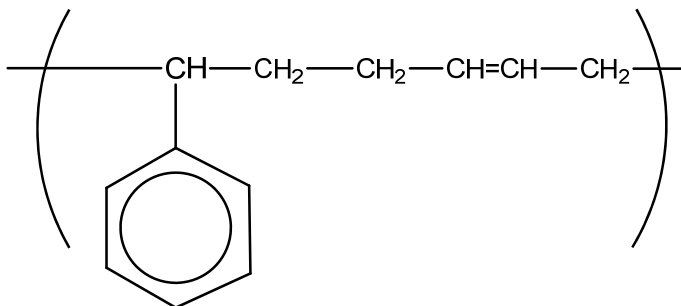


For PVC: $-\text{CH}_2-\text{CHCl}-\text{CH}_2-\text{CHCl}-$, C is sp^3 , C-C bonds are single bonds, C has higher p character hence the bonds are longer and weaker.

28 Which monomer co-polymerises with

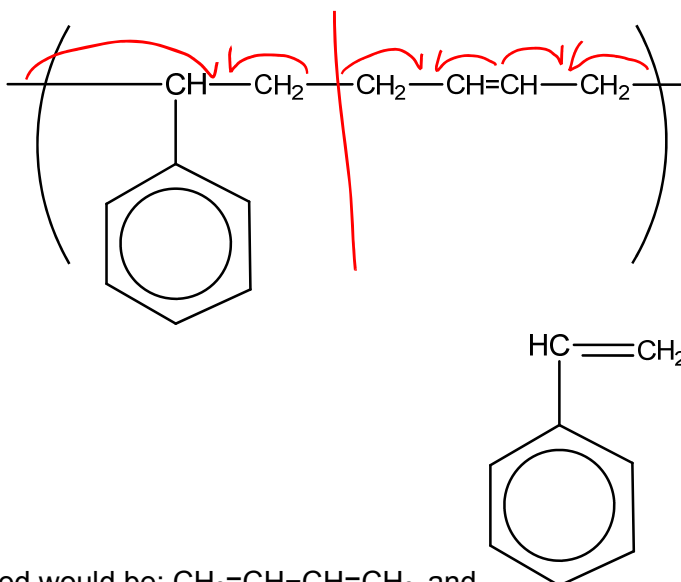


to give a polymer with the repeat unit shown below?



- A**
- B** $\text{CH}_3\text{-CH=CH-CH}_3$
- C** $\text{CH}_2=\text{CH-CH}_2\text{-CH}_3$
- D** $\text{CH}_2=\text{CH-CH=CH}_2$

Answer: D



Monomers formed would be: $\text{CH}_2=\text{CH-CH=CH}_2$ and

29 Which of the following statements are **incorrect**?

- 1 Graphene has low tensile strength.
- 2 Geckos are able to stick to walls as they form strong covalent bonds to the walls.
- 3 Catalytic converters have a honeycomb structure to maximize the surface area available for catalysis to take place.

A 1 and 2 only **B** 1 and 3 only **C** 1, 2 and 3 **D** 1 only

Answer: A

Option 1 is incorrect as it has high tensile strength as each carbon atom has strong

covalent bonds with three other carbon atoms.

Option 2 is incorrect as they form instantaneous dipole- induced dipole interactions with the wall.

Option 3 is correct as a honeycombed structure for catalyst in the catalytic converter is used so as to maximise the surface area on which heterogeneous catalysed reactions take place as the metals are very expensive.

30 What is the maximum size, in at least one dimension, of a nanomaterial?

A 1×10^{-6} m

B 1×10^{-7} m

C 1×10^{-8} m

D 1×10^{-9} m

Answer: **B**

Maximum size = 100 nm = 100×10^{-9} m = 1×10^{-7} m

Index No.	Name	Form Class	Tutorial Class	Subject Tutor
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ANGLO-CHINESE JUNIOR COLLEGE
DEPARTMENT OF CHEMISTRY
Preliminary Examination

CHEMISTRY
Higher 1

8873/02

Paper 2

16 August 2018
2 hours

Candidates answer on the Question Paper

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name, index number, form class, tutorial class and subject tutor's name on all the work you hand in.

Write in dark blue or black pen.

You may use a soft pencil for any diagrams, graphs or rough working.

Do not use staples, paper clips, glue or correction fluid.

Section A

Answer **all** the questions.

Section B

Answer **one** question.

The use of an approved scientific calculator is expected, where appropriate.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [] at the end of each question or part question.

For Examiner's Use	
Question no.	Marks
Section A	
B7	
B8	
Presentation of answers	
TOTAL	

This document consists of **22** printed pages and **2** blank pages.



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Section A

Answer **all** the questions in this section, in the spaces provided.

1 (a) Hydrogen sulfide, H₂S, is a foul-smelling compound found in the gases from volcanoes. Hydrogen sulfide has a melting point at -85°C and boiling point at -60°C.

(i) State the structure of hydrogen sulfide.

.....[1]

(ii) Draw a 'dot-and-cross' diagram to show the structure of H₂S.

[1]

(iii) State and explain the shape of H₂S.

.....
.....[2]

(iv) Oxygen and sulfur are both in Group 16 of the Periodic Table.

Suggest why the melting and boiling points of water, H₂O, are much higher than those of H₂S.

.....
.....
.....
.....
.....[3]

(b) Hydrogen sulfide burns with a blue flame in an excess of oxygen to form sulfur dioxide and water.

(i) Write a balanced equation for the complete combustion of H_2S .

.....[1]

(ii) What is the change in the oxidation number of sulfur in this reaction?

.....[1]

(iii) What volume of oxygen, measured at room temperature and pressure, is required for the complete combustion of 8.65 g of H_2S ? Give your answer to two decimal places.

[2]

(c) Hydrogen sulfide is a weak diprotic (dibasic) acid.

(i) What is meant by the term *weak acid*?

.....[1]

(ii) Write an equation, with state symbols, for the **first** ionisation of H_2S when it dissolves in water.

.....[1]

[Total: 13]

2 (a) In 2010 the Nobel Prize for Physics was awarded to two researchers from Manchester University for their work on preparing graphene from graphite.

(i) Graphene can be prepared from graphite by using sticky tape. Use your knowledge of the bonding in graphite to explain why it is possible to create graphene by this method.

.....[1]

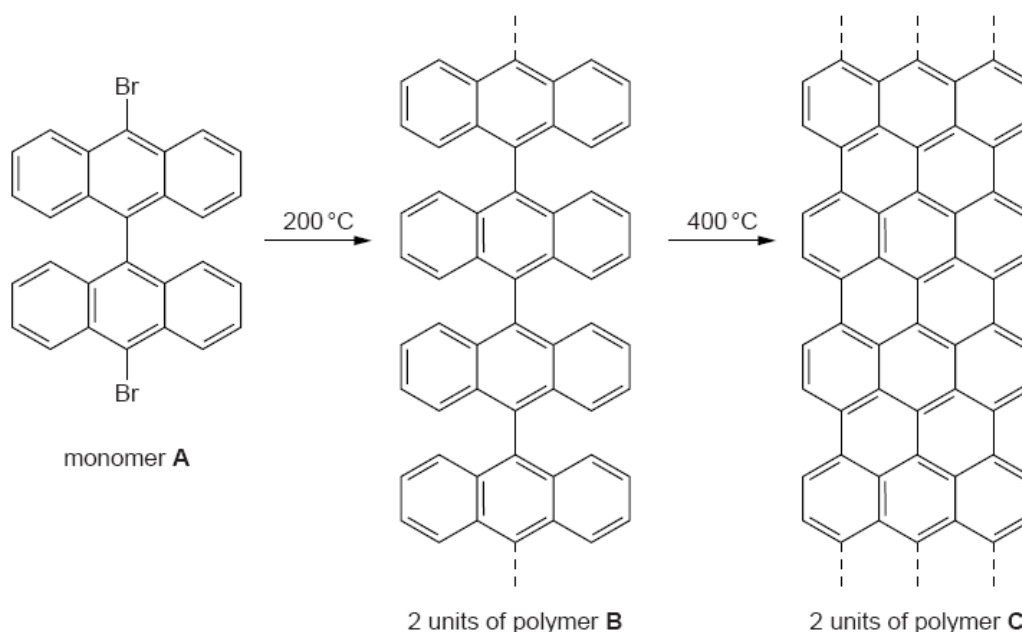
(ii) State one physical property of graphene and explain the reason.

.....

.....[2]

(b) A graphene sheet is a layer of graphite.

A recent development has been the synthesis of graphene ribbons (reported in *Nature*, 2010). A reaction scheme is shown.



(i) When monomer **A** is polymerised to make **B** there is also another product, **X**. Give the molecular formula of **X**.

[1]

(ii) In the transformation of polymer **B** into polymer **C**, another product, **Y**, is produced. Give the molecular formula of **Y**.

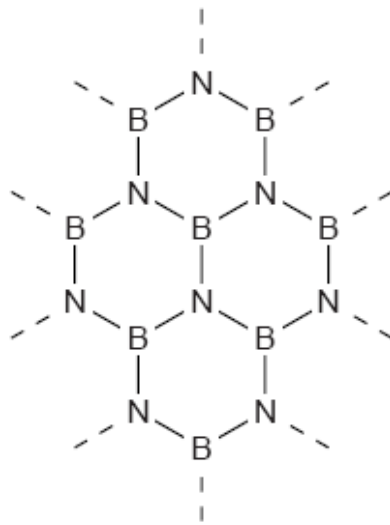
[1]

- (iii) Deduce the number of moles of **X** and **Y** produced **per mole of monomer A**.

[2]

- (iv) Boron nitride, BN, forms sheets similar to graphene except they contain dative covalent bonds as well as covalent bonds.

Add all the possible dative covalent bonds between the atoms shown in the structure below. [1]



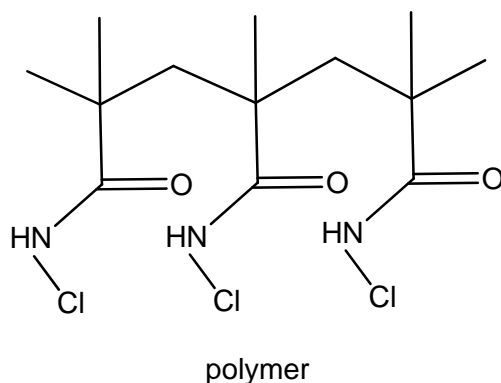
- (v) Boron nitride can also form a giant covalent structure in which each atom has four single bonds.

Suggest the name of another substance which has this type of structure.

.....[1]

[Total: 9]

- 3 Chemists have recently found a way of making the strong, light-weight and thermally stable polymer, Kevlar®, to be antibacterial (reported in *Industrial & Engineering Chemistry Research*, 2008). This was achieved by coating it with another polymer, a fragment of which is shown below.



- (a) Draw the repeat unit of the polymer structure shown above.

[1]

- (b) The polymer shown above is made by the following reactions:

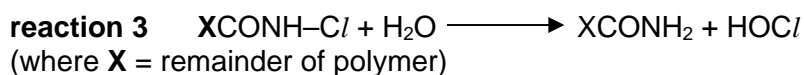
reaction 1 an addition polymerisation reaction of a monomer known as MAA
reaction 2 the substitution of a hydrogen atom in the polymer with a chlorine atom using bleach

Draw the structure of the monomer MAA.

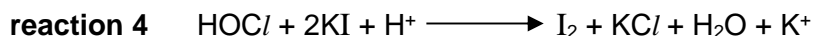
[1]

- (c) Not all the nitrogen atoms in the polymer end up bonded to a chlorine atom. The quantity of chlorine actually present in the polymer can be determined using **reactions 3, 4 and 5**.

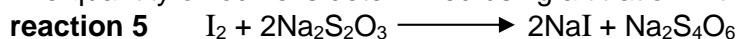
A known mass of polymer (written as XCONH-Cl) is reacted to convert the chlorine content of the polymer to chloric(I) acid, HOCl :



The chlorine content is then 'converted' to iodine:



The quantity of iodine is determined using a titration with sodium thiosulfate:



- (i) State the oxidation number of the chlorine in HOCl .

.....[1]

- (ii) State the type of reaction for **reaction 3** and **5**.

.....
.....[2]

- (iii) Write ionic half equations for the oxidation and reduction processes in **reaction 4**.

.....
.....[2]

In the analysis of a sample of polymer, 1.00 g of the polymer was reacted with steam. (**reaction 3**).

The resulting mixture was reacted with excess acidified potassium iodide (**reaction 4**) and then made up to 250 cm³ with distilled water.

25.0 cm³ of this solution reacted with exactly 25.00 cm³ of sodium thiosulfate solution of concentration 0.100 mol dm⁻³ (**reaction 5**).

(iv) Name a suitable indicator for the titration in **reaction 5** and state the colour change at end point.

.....
.....[2]

(v) Determine the amount of iodine in the 25.00 cm³ solution.

[1]

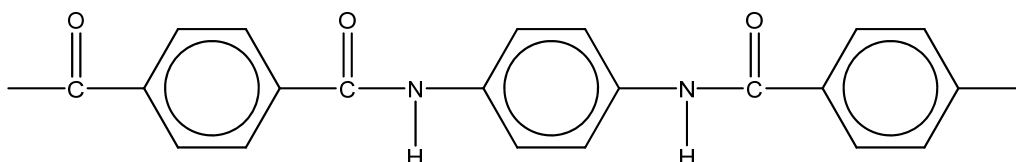
(vi) Determine the mass of chlorine present in the sample of polymer.

[2]

- (d) *Kevlar* is a synthetic polymer made from two monomers. It is a registered trademark of DuPont and was discovered in 1965. *Kevlar's* first commercial use was as a replacement for steel in racing tires.

Kevlar is used to make military equipment such as bulletproof vests, helmets, reinforcements for military vehicles and in making other light weight military equipment.

A portion of its chain is shown below.



- (i) What type of polymerisation produces *Kevlar*?

.....[1]

- (ii) Draw the structural formulae of the monomers from which *Kevlar* is made.

[2]

- (iii) With a labelled diagram, suggest a reason why *Kevlar* is much stronger than most other polyamides.

.....

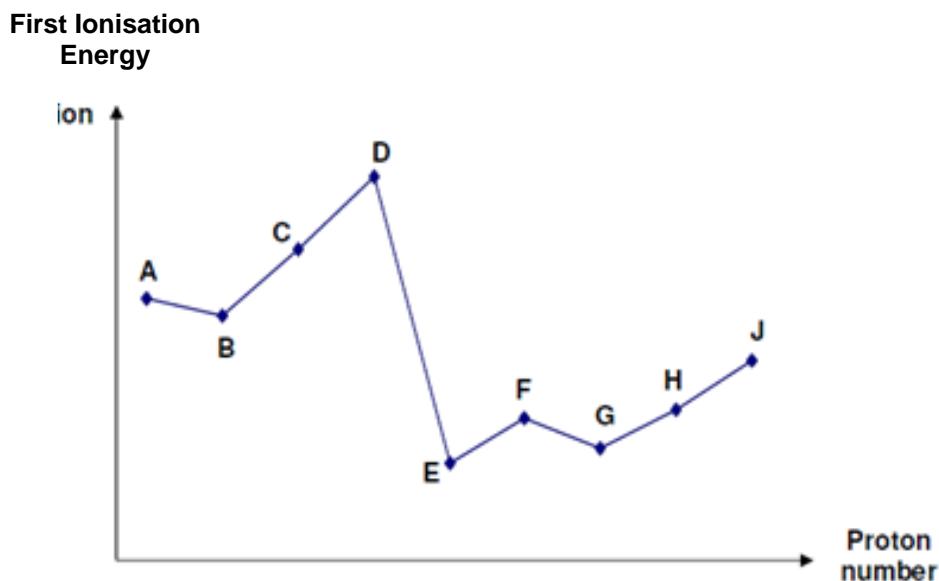
.....[2]

(iv) What reaction conditions are needed to break the amide bonds in *Kevlar*?

.....[1]

[Total: 18]

4 The first ionisation energies of nine consecutive elements **A** to **J** in Periods 2 and 3 of the Periodic Table are as shown.



(a) **A** and **J** are in the same group. Explain why the first ionisation energy of **J** is lower than that of **A**.

.....

[1]

(b) The oxide of **H** is insoluble in water while its chloride reacts completely with aqueous sodium hydroxide to give a resulting mixture of pH close to 7.

(i) To which group does **H** belong?

.....[1]

(ii) Using the symbol **H**, write the formula of the oxide of **H**.

.....[1]

(c) **J** can form different chlorides of JCl_3 and JCl_5 .

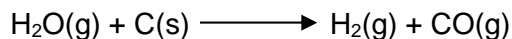
State the pH of the resultant mixture when the chloride of **G** and one of the chlorides of **J** is added to water separately. Write an equation for each to support your answer.

	chloride of G	chloride of J
pH of solution formed when added to water		
Equation to show reaction with water (if any)		

[4]

[Total: 7]

- 5 'Water gas' is an equimolar mixture of hydrogen and carbon monoxide. It is used as an industrial gaseous fuel. It is produced when steam is blown through white-hot coke in the following reaction.



Another widely-used industrial fuel is natural gas, which consists mainly of methane.

The enthalpy changes of combustion of methane, hydrogen and carbon monoxide are -890 kJ mol^{-1} , -242 kJ mol^{-1} and -283 kJ mol^{-1} respectively.

- (a) Using the above enthalpy changes, calculate the volume of methane (measured at 20°C and 1 atm) required to produce 1 MJ (1000 kJ) of heat energy when burned.

[2]

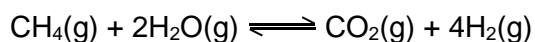
- (b) Calculate the volume of water gas (measured at 20°C and 1 atm) required to produce the same amount of heat energy.

[2]

- (c) Suggest **one** advantage of using natural gas rather than water gas.

.....
[1]

- (d) An industrially important source of hydrogen is shown in the reaction below.



Using the above enthalpy changes of combustion, determine the enthalpy change of this reaction.

[1]

[Total: 6]

- 6 **K, L, M** and **N** are consecutive elements of increasing proton number in the Periodic Table.

- (a) The successive ionisation energies, in kJ mol^{-1} of element **L** are given below.

1681 3374 6050 8407 11020 15160 17870 92040 106400

To which Group does element **L** belong? Explain your answer.

.....

[2]

- (b) **K, L** and **N** form ions that are isoelectronic with atom **M**.

- (i) State the charge on the ions of **K, L** and **N**. [2]

K: **L:** **N:**

- (ii) Arrange the ions of **K, L** and **N** in *decreasing* order of ionic radius. Explain your answers.

.....

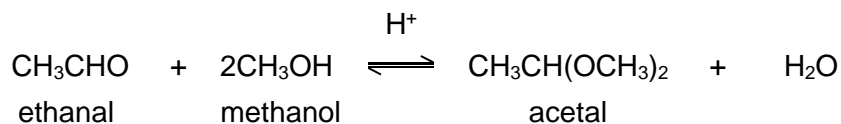
[3]

[Total: 7]

Section B

Answer **one** question from this section, in the spaces provided.

- 7 Acetals are compounds formed when aldehydes are reacted with an alcohol in the presence of an acid catalyst. The reaction between ethanal and methanol was studied in the inert solvent dioxan.



- (a) In an experiment, the concentrations of the reactants and products were measured. The results are shown in the table below.

	[CH ₃ CHO]/ mol dm ⁻³	[CH ₃ OH]/ mol dm ⁻³	[H ⁺]/ mol dm ⁻³	[acetal]/ mol dm ⁻³	[H ₂ O]/ mol dm ⁻³
at start	0.20	0.10	0.05	0.00	0.00
change	-0.025				
at equilibrium					

- (i) Complete the blanks in the table. [2]
- (ii) Write the expression for the equilibrium constant for this reaction, K_c , stating its units. [2]

- (iii) Calculate the value of K_c . [1]

(iv) State *Le Chatelier's principle*.

.....

[1]

(v) Given a fixed temperature, state whether an increase in concentration for the acid catalyst will affect the value of the equilibrium constant.

.....[1]

(b) When the initial rate of this reaction was measured at various starting concentrations of the three reactants, the following results were obtained.

experiment number	[CH ₃ CHO]/ mol dm ⁻³	[CH ₃ OH]/ mol dm ⁻³	[H ⁺]/ mol dm ⁻³	relative rate
1	0.20	0.10	0.05	1.00
2	0.25	0.10	0.05	1.25
3	0.25	0.16	0.05	2.00
4	0.20	0.16	0.10	3.20

(i) Use the data in the table to determine the order with respect to each reactant.

[3]

(ii) Write the rate equation for the reaction.

.....[1]

(iii) State the units of the rate constant in the rate equation given that the rate is expressed in terms of $\text{mol dm}^{-3} \text{s}^{-1}$.

[1]

(iv) Explain with the aid of energy profile curves in the same axis how the presence of the acid catalyst will affect the rate constant. Assume that the reaction is exothermic.

.....
.....
.....[4]

(c) Ethanal and methanol can be oxidised using acidified potassium dichromate(VI).

(i) Draw the displayed formulae of the organic products formed.

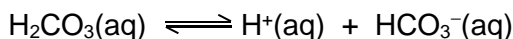
[2]

(ii) Write equations for both the reactions and state the colour change for the reaction.

[2]

[Total: 20]

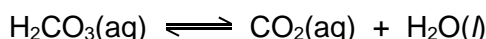
- 8 Blood plasma is a biological fluid that plays an important role in maintaining pH in the body. In the blood plasma, the equilibrium between carbonic acid, $\text{H}_2\text{CO}_3(\text{aq})$, and hydrogencarbonate ion, $\text{HCO}_3^-(\text{aq})$, buffers pH changes.



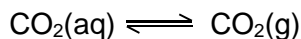
The K_a for this equilibrium is $7.90 \times 10^{-7} \text{ mol dm}^{-3}$.

At body temperature, the pH of the arterial blood plasma is 7.40. If the pH falls below this normal value, a condition termed *acidosis* is produced. If the pH rises above this normal value, the condition is termed *alkalosis*.

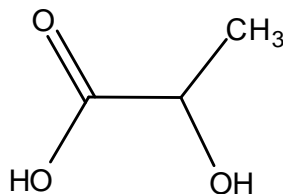
The concentration of $\text{H}_2\text{CO}_3(\text{aq})$ is controlled by respiration through the lungs. $\text{H}_2\text{CO}_3(\text{aq})$ is in equilibrium with dissolved CO_2 .



In the lungs, excess dissolved $\text{CO}_2(\text{aq})$ is exhaled as $\text{CO}_2(\text{g})$.



During heavy exercise, *lactic acid* is released into the blood and is buffered by the blood plasma.



Lactic acid

This eventually leads to an increase in $\text{CO}_2(\text{aq})$ concentration and stimulates increased breathing.

- (a) (i) Explain what is meant by a *buffer solution* in the context of blood plasma.

.....
[2]

- (ii) Write an equation to show how blood plasma can buffer the pH change when lactic acid is released into the blood.

.....[1]

- (iii) Write an expression for the acid dissociation constant, K_a , of $\text{H}_2\text{CO}_3(\text{aq})$ and use it to determine the $[\text{HCO}_3^-(\text{aq})]/[\text{H}_2\text{CO}_3(\text{aq})]$ ratio in the blood plasma.

Comment on this ratio.

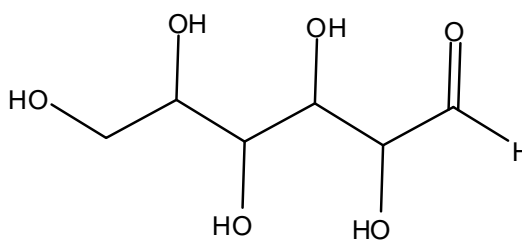
[3]

- (iv) Using the information given, explain, with the aid of two equations, how the production of lactic acid leads to the increase in rate of breathing.

.....

[2]

- (b) Lactic acid is converted to *glucose* via gluconeogenesis in the liver.



Glucose

- (i) Name the functional group(s) present in glucose.

.....[2]

(ii) Draw the skeletal formula of the organic products when *glucose* is added to

(I) $\text{H}_2\text{SO}_4(\text{aq})$, K_2CrO_7 , heat

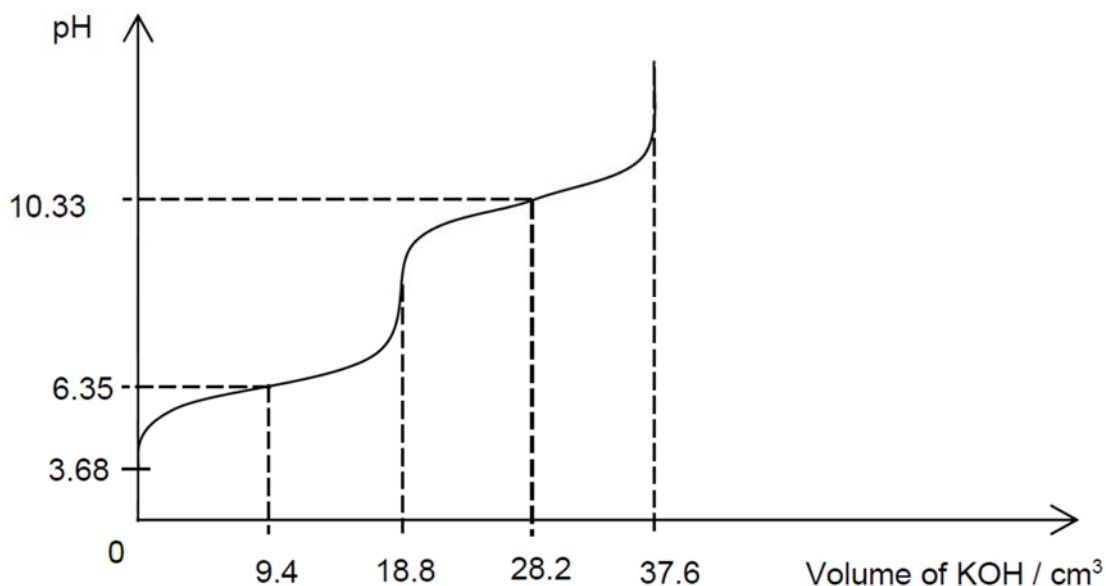
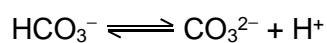
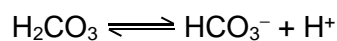
(II) LiAlH_4 , dry ether, reflux

[2]

(iii) Describe a simple chemical test that you could use to distinguish between lactic acid and glucose. You are to include reagents and conditions, observations and balanced equation(s) in each case.

.....
.....
.....
.....
.....[3]

- (c) In an experiment, 25 cm³ of 0.100 mol dm⁻³ H₂CO₃ is titrated with aqueous potassium hydroxide. The titration curve is shown below. The acid dissociation of H₂CO₃ is as shown in the following equations.



- (i) Justify that carbonic acid, H₂CO₃, is a weak acid with relevant calculations.

[2]

- (ii) Calculate the concentration of KOH, in mol dm⁻³, used in the titration.

[1]

(iii) Suggest, with a reason, a suitable indicator for the first end point of this titration.

.....

.....

.....[2]

[Total: 20]

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Index No.	Name	Form Class	Tutorial Class	Subject Tutor
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ANGLO-CHINESE JUNIOR COLLEGE
DEPARTMENT OF CHEMISTRY
Preliminary Examination

CHEMISTRY
Higher 1

8873/02

Paper 2

16 August 2018
2 hours

Candidates answer on the Question Paper

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name, index number, form class, tutorial class and subject tutor's name on all the work you hand in.

Write in dark blue or black pen.

You may use a soft pencil for any diagrams, graphs or rough working.

Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Section A

Answer **all** the questions.

Section B

Answer **one** question.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [] at the end of each question or part question.

For Examiner's Use	
Question no.	Marks
Section A	
B7	
B8	
TOTAL	

This document consists of **16** printed pages.



Section A

Answer **all** the questions in this section, in the spaces provided.

- 1 (a) Hydrogen sulfide, H_2S , is a foul-smelling compound found in the gases from volcanoes. Hydrogen sulfide has a melting point at $-85\text{ }^\circ\text{C}$ and boiling point at $-60\text{ }^\circ\text{C}$.

- (i) State the structure of hydrogen sulfide. [1]

Simple covalent/ molecular structure

- (ii) Draw a 'dot-and-cross' diagram to show the structure of H_2S . [1]



- (iii) State and explain the shape of H_2S . [2]

Bent

There are two bond pairs and two lone pairs of electron around the central atom S.

- (iv) Oxygen and sulfur are both in Group 16 of the Periodic Table.

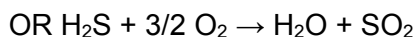
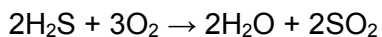
Suggest why the melting and boiling points of water, H_2O , are much higher than those of H_2S . [3]

There are stronger hydrogen bonds between H_2O molecules and there are weaker permanent dipole- permanent dipole interactions between H_2S molecules.

More energy is needed to overcome the stronger hydrogen bonds between water molecules compared to the pd-pd interactions.

- (b) Hydrogen sulfide burns with a blue flame in an excess of oxygen to form sulfur dioxide and water.

- (i) Write a balanced equation for the complete combustion of H_2S . [1]



- (ii) What is the change in the oxidation number of sulfur in this reaction? [1]

-2 to +4 OR +6 OR increase the oxidation state by +6

- (iii) What volume of oxygen, measured at room temperature and pressure, is required for the complete combustion of 8.65 g of H₂S? Give your answer to two decimal places. [2]

$$\text{Amount of H}_2\text{S} = 8.65 / 34.1 = 0.25367 \text{ mol}$$

$$\text{Mole ratio of H}_2\text{S: O}_2 = 2:3$$

$$\text{Amount of oxygen} = 3/2 \times 0.25367 = 0.380499 \text{ mol}$$

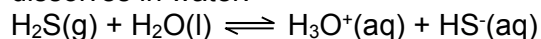
$$\text{Volume of oxygen} = 0.380499 \times 24 = 9.13 \text{ dm}^3$$

- (c) Hydrogen sulfide is a weak diprotic (dibasic) acid.

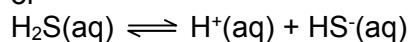
- (i) What is meant by the term *weak acid*? [1]

A weak acid undergoes partial dissociation in water to give H⁺ ions/ proton donor.

- (ii) Write an equation, with state symbols, for the **first** ionisation of H₂S when it dissolves in water. [1]



or



[Total: 13]

- 2 (a) In 2010 the Nobel Prize for Physics was awarded to two researchers from Manchester University for their work on preparing graphene from graphite.

- (i) Graphene can be prepared from graphite by using sticky tape. Use your knowledge of the bonding in graphite to explain why it is possible to create graphene by this method. [1]

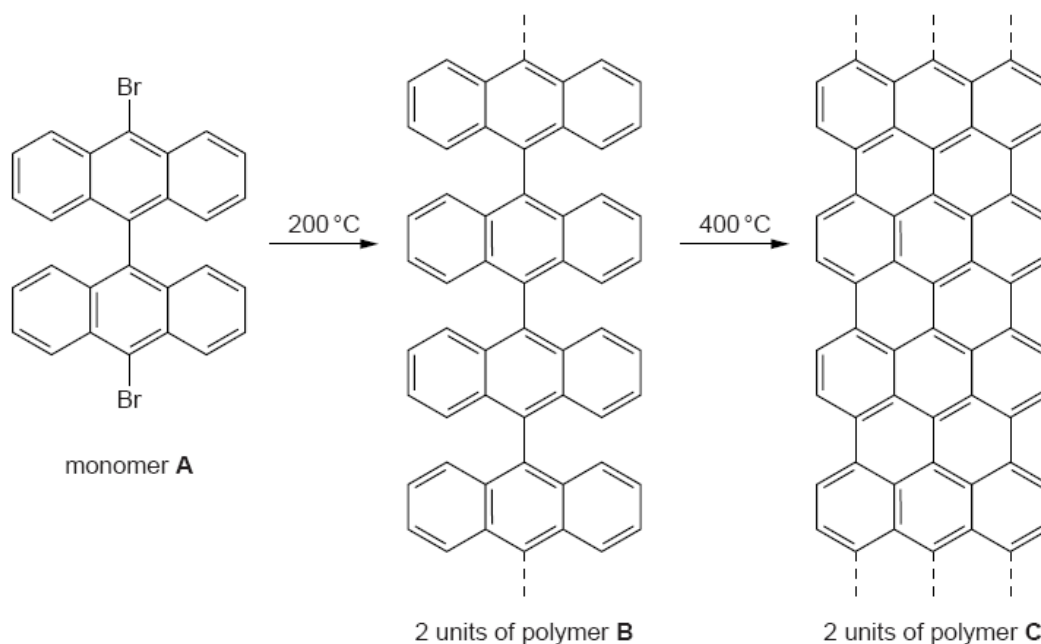
Weak id-id interactions between graphene sheets in graphite

- (ii) State one physical property of graphene and explain the reason. [2]

- High tensile strength (reason: strong covalent bonds between atom)
- OR
- Excellent electrical conductivity (reason: p electron per carbon atom)

- (b) A graphene sheet is a layer of graphite.

A recent development has been the synthesis of graphene ribbons (reported in *Nature*, 2010). A reaction scheme is shown.



- (i) When monomer **A** is polymerised to make **B** there is also another product, **X**. Give the molecular formula of **X**. [1]

Br_2

- (ii) In the transformation of polymer **B** into polymer **C**, another product, **Y**, is produced. Give the molecular formula of **Y**. [1]

H_2

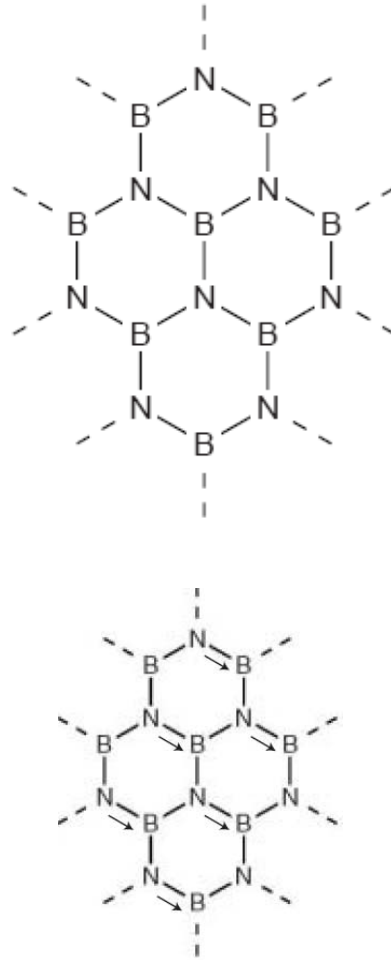
- (iii) Deduce the number of moles of **X** and **Y** produced **per mole of monomer A**. [2]

No. of moles of **X** = 1

No. of moles of **Y** = 4

- (iv) Boron nitride, BN, forms sheets similar to graphene except they contain dative covalent bonds as well as covalent bonds.

Add all the possible dative covalent bonds between the atoms shown in the structure below. [1]



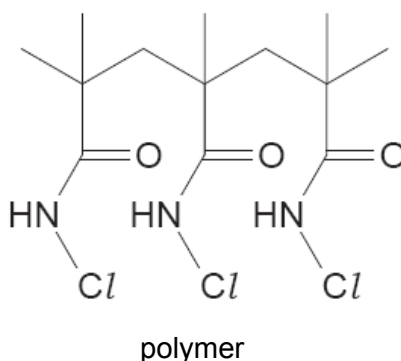
- (v) Boron nitride can also form a giant covalent structure in which each atom has four single bonds.

Suggest the name of another substance which has this type of structure.
[1]

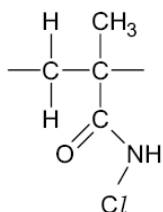
Diamond or silicon or silicon dioxide

[Total: 9]

- 3 Chemists have recently found a way of making the strong, light-weight and thermally stable polymer, Kevlar®, to be antibacterial (reported in *Industrial & Engineering Chemistry Research*, 2008). This was achieved by coating it with another polymer, a fragment of which is shown below.



- (a) Draw the repeat unit of the polymer structure shown above. [1]

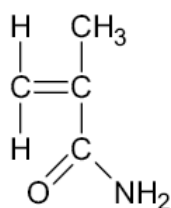


- (b) The polymer shown above is made by the following reactions:

reaction 1 an addition polymerisation reaction of a monomer known as MAA
reaction 2 the substitution of a hydrogen atom in the polymer with a chlorine atom using bleach

Draw the structure of the monomer MAA.

[1]

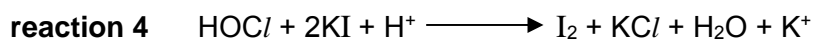


- (c) Not all the nitrogen atoms in the polymer end up bonded to a chlorine atom. The quantity of chlorine actually present in the polymer can be determined using **reactions 3, 4 and 5**.

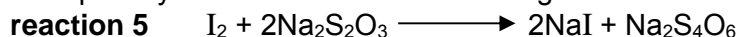
A known mass of polymer (written as $XCONH-Cl$) is reacted to convert the chlorine content of the polymer to chloric(I) acid, $HOCl$:

reaction 3 $XCONH-Cl + H_2O \longrightarrow XCONH_2 + HOCl$
 (where X = remainder of polymer)

The chlorine content is then 'converted' to iodine:



The quantity of iodine is determined using a titration with sodium thiosulfate:



- (i) State the oxidation number of the chlorine in HOCl. [1]
+1
- (ii) State the type of reaction for **reaction 3** and **5**. [2]
Reaction 3 – hydrolysis
Reaction 5 – redox
- (iii) Write ionic half equations for the oxidation and reduction processes in **reaction 4**. [2]
Oxidation: $2\text{I}^- \rightarrow \text{I}_2 + 2\text{e}^-$
Reduction: $\text{ClO}^- + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{Cl}^- + \text{H}_2\text{O}$
Or $\text{HOCl} + \text{H}^+ + 2\text{e}^- \rightarrow \text{Cl}^- + \text{H}_2\text{O}$

In the analysis of a sample of polymer, 1.00 g of the polymer was reacted with steam. (**reaction 3**).

The resulting mixture was reacted with excess acidified potassium iodide (**reaction 4**) and then made up to 250 cm³ with distilled water.

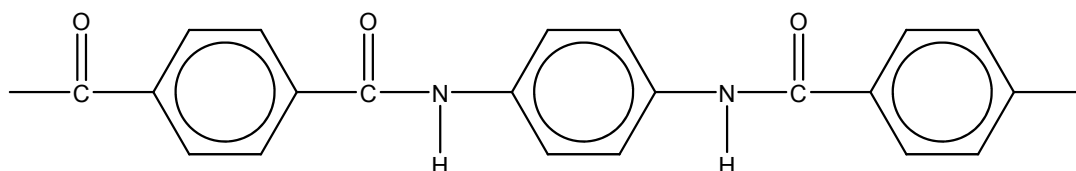
25.0 cm³ of this solution reacted with exactly 25.00 cm³ of sodium thiosulfate solution of concentration 0.100 mol dm⁻³ (**reaction 5**).

- (iv) Name a suitable indicator for the titration in **reaction 5** and state the colour change at end point. [2]
Starch
dark-blue to colourless
- (v) Determine the amount of iodine in the 25.00 cm³ solution. [1]
Amount of thiosulfate = $25.0/1000 \times 0.100 = 0.0025$ mol
 $\text{I}_2 + 2\text{Na}_2\text{S}_2\text{O}_3 \rightarrow 2\text{NaI} + \text{Na}_2\text{S}_4\text{O}_6$
Amount of iodine in 25.0 cm³ = $0.0025 \text{ mol} / 2 = 0.00125$ mol
- (vi) Determine the mass of chlorine present in the sample of polymer. [2]
Amount of iodine in 250 cm³ = $0.00125 \times 10 = 0.0125$ mol
 $\text{XCONH-Cl} + \text{H}_2\text{O} \rightarrow \text{XCONH}_2 + \text{HOCl}$
 $\text{HOCl} + 2\text{KI} + \text{H}^+ \rightarrow \text{I}_2 + \text{KCl} + \text{H}_2\text{O} + \text{K}^+$
Amount of chlorine = 0.0125 mol
Mass of chlorine = $0.0125 \times 35.5 = 0.444$ g

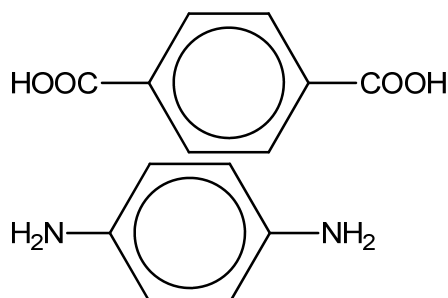
- (d) *Kevlar* is a synthetic polymer made from two monomers. It is a registered trademark of DuPont and was discovered in 1965. *Kevlar's* first commercial use was as a replacement for steel in racing tires.

Kevlar is used to make military equipment such as bulletproof vests, helmets, reinforcements for military vehicles and in making other light weight military equipment.

A portion of its chain is shown below.



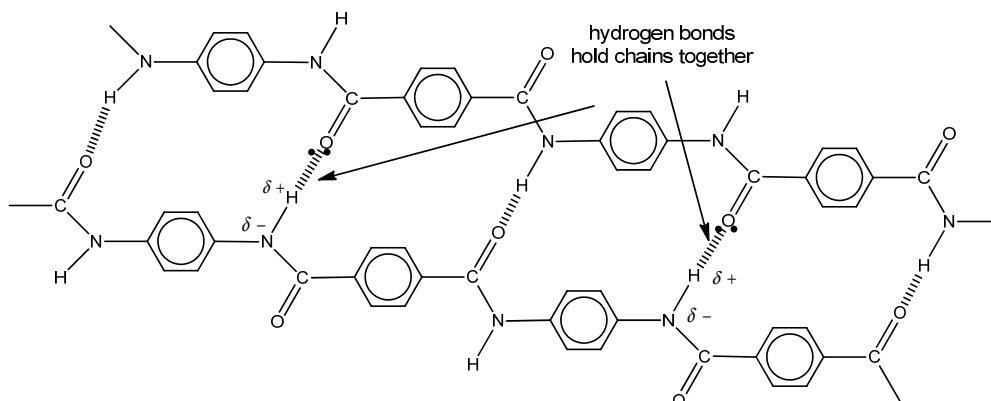
- (i) What type of polymerisation produces *Kevlar*? [1]
Condensation
- (ii) Draw the structural formulae of the monomers from which *Kevlar* is made. [2]



- (iii) With a labelled diagram, suggest a reason why *Kevlar* is much stronger than most other polyamides. [2]

Kevlar is strong as there are intermolecular forces between the chains due to hydrogen bonds. This leads to compact packing or polymers are closely packed.

The chains of rigid, linear molecules line up together parallel to one another, held together by hydrogen bonds which leads to sheets of molecules.

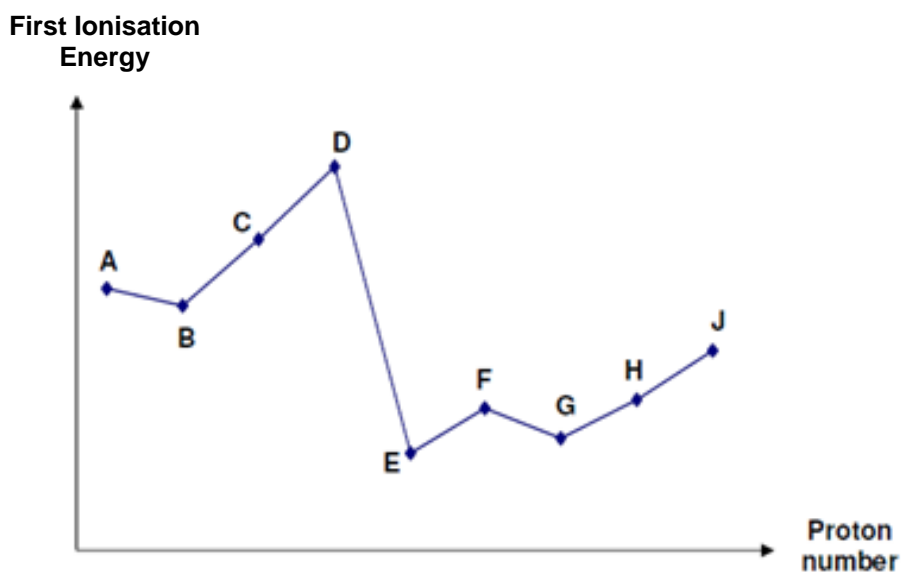


- (iv) What reaction conditions are needed to break the amide bonds in *Kevlar*?
[1]

Heat/ warm with aq/dilute H_2SO_4 / H^+ or OH^- / NaOH

[Total: 18]

- 4 The first ionisation energies of nine consecutive elements **A** to **J** in Periods 2 and 3 of the Periodic Table are as shown.



- (a) **A** and **J** are in the same group. Explain why the first ionisation energy of **J** is lower than that of **A**. [1]

.....

J has an extra quantum shell; the valence electrons are further away from nucleus and less strongly attracted and thus a lower IE.

- (b) The oxide of **H** is insoluble in water while its chloride reacts completely with aqueous sodium hydroxide to give a resulting mixture of pH close to 7.

- (i) To which group does **H** belong? [1]

14

- (ii) Using the symbol **H**, write the formula of the oxide of **H**. [1]

HO_2 OR SiO_2

- (c) **J** can form different chlorides of JC_3 and JC_5 .

State the pH of the resultant mixture when the chloride of **G** and one of the

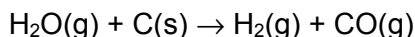
chlorides of **J** is added to water separately. Write an equation for each to support your answer. [4]

	Chloride of G	Chloride of J
pH of solution formed when added to water		
Equation to show reaction with water (if any)		

	Chloride of G	Chloride of J
pH of solution formed when added to water	3	1 or 2
Equation to show reaction with water (if any)	$\text{GC}_3 + 6\text{H}_2\text{O} \rightarrow [\text{G}(\text{H}_2\text{O})_6]^{3+} + 3\text{Cl}^-$ $[\text{G}(\text{H}_2\text{O})_6]^{3+} \rightleftharpoons [\text{G}(\text{H}_2\text{O})_5\text{OH}]^{2+} + \text{H}^+$ or $\text{GC}_3 + 3\text{H}_2\text{O} \rightarrow \text{G}(\text{OH})_3 + 3\text{HCl}$	$\text{JC}_3 + 3\text{H}_2\text{O} \rightarrow \text{H}_3\text{JO}_3 + 3\text{HCl}$ $\text{JC}_5 + 4\text{H}_2\text{O} \rightarrow \text{H}_3\text{JO}_4 + 5\text{HCl}$

[Total: 7]

- 5 'Water gas' is an equimolar mixture of hydrogen and carbon monoxide. It is used as an industrial gaseous fuel. It is produced when steam is blown through white-hot coke in the following reaction.



Another widely-used industrial fuel is natural gas, which consists mainly of methane.

The enthalpy changes of combustion of methane, hydrogen and carbon monoxide are -890 kJ mol^{-1} , -242 kJ mol^{-1} and -283 kJ mol^{-1} respectively.

- (a) Using the above enthalpy changes, calculate the volume of methane (measured at 20°C and 1 atm) required to produce 1 MJ (1000 kJ) of heat energy when burned. [2]

No. of moles of methane needed to produce 1000 kJ of heat
 = $1000 / 890 = 1.124 \text{ mol}$

Volume of methane required = $1.124 \times 24 = \underline{27.0 \text{ dm}^3}$

- (b) Calculate the volume of water gas (measured at 20 °C and 1 atm) required to produce the same amount of heat energy. [2]

1 mol of water gas contains $\frac{1}{2}$ mol of H₂ and $\frac{1}{2}$ mol of CO.

Amount of heat given off when 1 mol of water gas is burnt
 = $\frac{1}{2} (242) + \frac{1}{2} (283) = 262.5 \text{ kJ}$

amt of water gas needed to produce 1000 kJ of heat
 = $1000 / 262.5 = 3.81 \text{ mol}$

Volume of water gas required = $3.81 \times 24 = \underline{91.4 \text{ dm}^3}$

- (c) Suggest **one** advantage of using natural gas rather than water gas. [1]

Natural gas is cheaper to use as it is found naturally. Water gas has to be manufactured by passing steam over white hot coke.

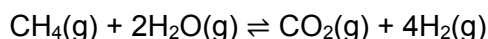
OR

Natural gas releases more energy per unit volume than water gas.

OR

Natural gas is not toxic while CO is toxic.

- (d) An industrially important source of hydrogen is shown in the reaction below.



Using the above enthalpy changes of combustion, determine the enthalpy change of this reaction. [1]

$$\begin{aligned} \text{Enthalpy change of reaction} &= -890 - 4(-242) \\ &= \underline{\underline{+78.0 \text{ kJ mol}^{-1}}} \end{aligned}$$

[Total: 6]

- 6 **K, L, M** and **N** are consecutive elements of increasing proton number in the Periodic Table.

- (a) The successive ionisation energies, in kJ mol⁻¹ of element **L** are given below.

1681 3374 6050 8407 11020 15160 17870 92040 106400

To which Group does element **L** belong? Explain your answer. [2]

.....

.....
 Group 17 as the highest jump in ionisation energies is between 7th and 8th electron. 8th electron is found in the inner quantum shell and need more energy to remove it.

(b) K, L and N form ions that are isoelectronic with atom M.

(i) State the charge on the ions of K, L and N. [2]

K: L: N:

K: 2- L: 1- N: 1+

(ii) Arrange the ions of K, L and N in *decreasing* order of ionic radius. Explain your answers. [3]

.....

Ionic radius: $K^{2-} > L^{-} > N^{+}$

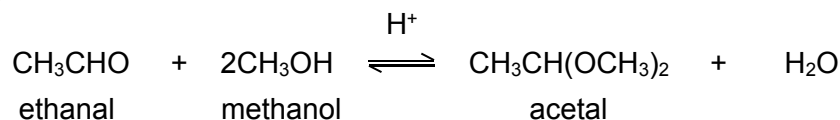
All 3 ions are isoelectronic while the nuclear charges increases from K^{2-} to L^{-} to N^{+} ; thus stronger forces of attraction between valence e's and nucleus.

[Total: 7]

Section B

Answer **one** question from this section, in the spaces provided.

- 7 Acetals are compounds formed when aldehydes are reacted with an alcohol in the presence of an acid catalyst. The reaction between ethanal and methanol was studied in the inert solvent dioxan.

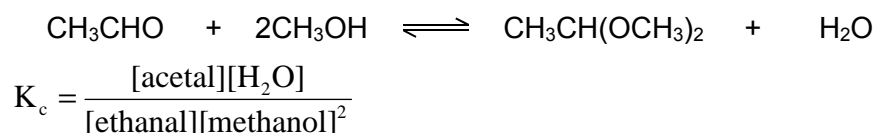


- (a) In an experiment, the concentrations of the reactants and products were measured. The results are shown in the table below.

	[CH ₃ CHO]/ mol dm ⁻³	[CH ₃ OH]/ mol dm ⁻³	[H ⁺]/ mol dm ⁻³	[acetal]/ mol dm ⁻³	[H ₂ O]/ mol dm ⁻³
at start	0.20	0.10	0.05	0.00	0.00
change	-0.025	-0.05	0	+0.025	+0.025
at equilibrium	0.175	0.05	0.05	0.025	0.025

- (i) Complete the blanks in the table. [2]

- (ii) Write the expression for the equilibrium constant for this reaction, K_c , stating its units. [2]



Units: mol⁻¹ dm³

- (iii) Calculate the value of K_c . [1]

$$K_c = \frac{[0.025][0.025]}{[0.175][0.05]^2} = 1.43$$

- (iv) State *Le Chatelier's principle*. [1]

Le Chatelier's Principle states that if a system in dynamic equilibrium is subjected to a change which disturbs the equilibrium, the system responds in such a way to counteract the effect of the change.

- (v) Given a fixed temperature, state whether an increase in concentration for the acid catalyst will affect the value of the equilibrium constant. [1]

No effect on the equilibrium constant.

- (b) When the initial rate of this reaction was measured at various starting concentrations of the three reactants, the following results were obtained.

experiment number	[CH ₃ CHO]/ mol dm ⁻³	[CH ₃ OH]/ mol dm ⁻³	[H ⁺]/ mol dm ⁻³	relative rate
1	0.20	0.10	0.05	1.00
2	0.25	0.10	0.05	1.25
3	0.25	0.16	0.05	2.00
4	0.20	0.16	0.10	3.20

- (i) Use the data in the table to determine the order with respect to each reactant. [3]

Comparing expt 1 and 2, increasing [CH₃CHO] by 1.25 and keeping the [H⁺] and [CH₃OH] constant, the relative rate also increases by 1.25. Hence first order with respect to CH₃CHO.

Comparing expt 2 and 3, increasing [CH₃OH] by 1.6, keeping the [H⁺] and [CH₃CHO] constant, the relative rate increases by 1.6. Hence first order with respect to CH₃OH.

Comparing expt 1 and 4, increasing [CH₃OH] by 1.6 and increasing [H⁺] by 2, keeping [CH₃CHO] constant, the relative rate increases by 3.2. Hence first order with respect to H⁺.

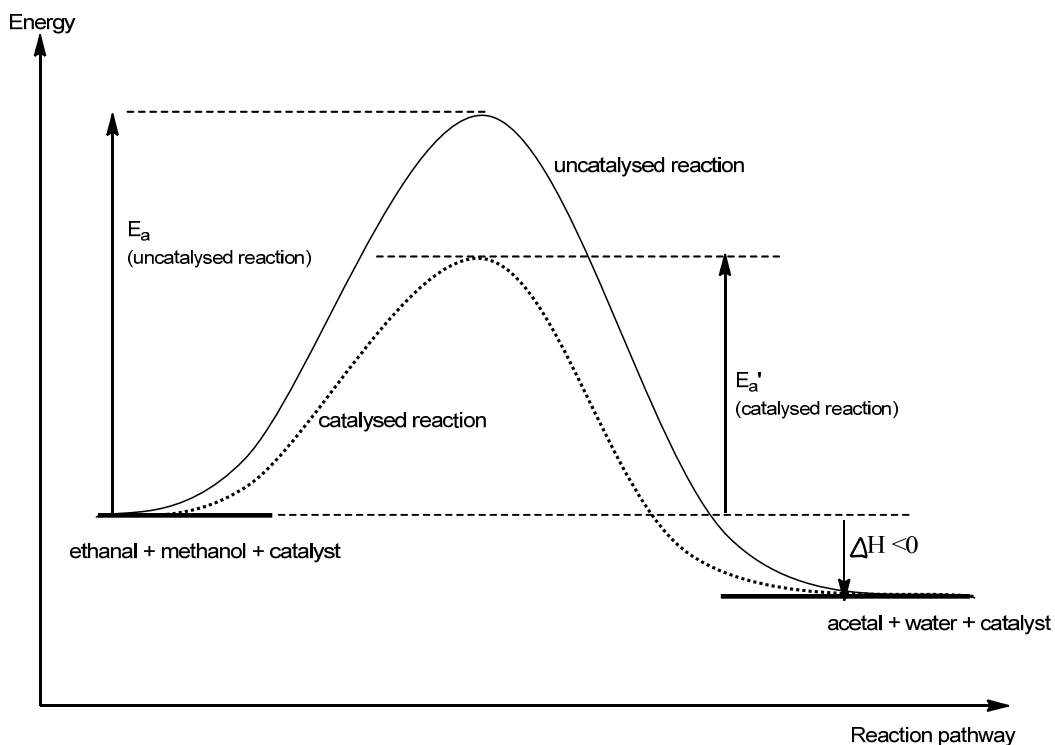
- (ii) Write the rate equation for the reaction. [1]



- (iii) State the units of the rate constant in the rate equation given that the rate is expressed in terms of mol dm⁻³ s⁻¹. [1]

$$\begin{aligned} \text{rate} &= k[\text{CH}_3\text{CHO}][\text{CH}_3\text{OH}][\text{H}^+] \\ \text{mol dm}^{-3} \text{ s}^{-1} &= k (\text{mol dm}^{-3})^3 \\ \text{units of rate constant} &= \text{mol}^{-2} \text{ dm}^6 \text{ s}^{-1} \end{aligned}$$

- (iv) Explain with the aid of energy profile curves in the same axis how the presence of the acid catalyst will affect the rate constant. Assume that the reaction is exothermic. [4]



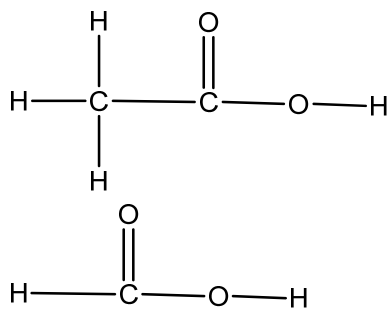
Arrhenius equation is given as:

$$k = Ae^{-\frac{E_a}{RT}}$$

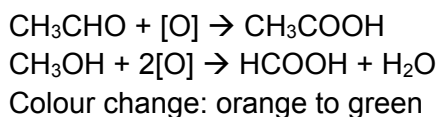
Rate constant is increased. An acid catalyst will decrease activation energy, E_a . More particles with energy $\geq E_a$ increase and frequency of effective collisions increase and increase the rate constant.

(c) Ethanal and methanol can be oxidised using acidified potassium dichromate(VI).

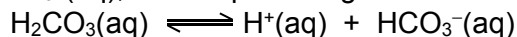
(i) Draw the displayed formulae of the organic products formed. [2]



(ii) Write the equations for the reaction and state the colour change for the reaction. [2]



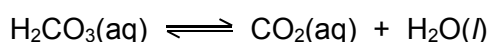
- 8 Blood plasma is a biological fluid that plays an important role in maintaining pH in the body. In the blood plasma, the equilibrium between carbonic acid, $\text{H}_2\text{CO}_3(\text{aq})$, and hydrogencarbonate ion, $\text{HCO}_3^-(\text{aq})$, buffers pH changes.



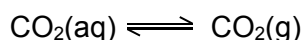
The K_a for this equilibrium is $7.90 \times 10^{-7} \text{ mol dm}^{-3}$.

At body temperature, the pH of the arterial blood plasma is 7.40. If the pH falls below this normal value, a condition termed *acidosis* is produced. If the pH rises above this normal value, the condition is termed *alkalosis*.

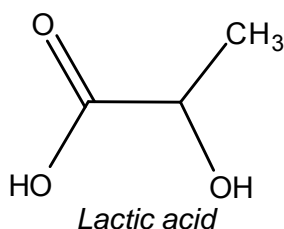
The concentration of $\text{H}_2\text{CO}_3(\text{aq})$ is controlled by respiration through the lungs. $\text{H}_2\text{CO}_3(\text{aq})$ is in equilibrium with dissolved CO_2 .



In the lungs, excess dissolved $\text{CO}_2(\text{aq})$ is exhaled as $\text{CO}_2(\text{g})$.



During heavy exercise, *lactic acid* is released into the blood and is buffered by the blood plasma.



This eventually leads to an increase in $\text{CO}_2(\text{aq})$ concentration and stimulates increased breathing.

- (a) (i) Explain what is meant by a *buffer solution* in the context of blood plasma. [2]

Blood plasma contains buffer solution that is made up of a large reservoir of weak acid $\text{H}_2\text{CO}_3(\text{aq})$ and its conjugate base, $\text{HCO}_3^-(\text{aq})$ which maintains a fairly constant pH when a small amount of acid or base is added.

- (ii) Write an equation to show how blood plasma can buffer the pH change when lactic acid is released into the blood. [1]



- (iii) Write an expression for the acid dissociation constant, K_a , of $\text{H}_2\text{CO}_3(\text{aq})$ and use it to determine the $[\text{HCO}_3^-(\text{aq})]/[\text{H}_2\text{CO}_3(\text{aq})]$ ratio in the blood plasma.

Comment on this ratio. [3]

$$K_a = \frac{[\text{HCO}_3^-][\text{H}^+]}{[\text{H}_2\text{CO}_3]}$$

$$\text{pH} = 7.4 \Rightarrow [\text{H}^+] = 10^{-7.4} \text{ mol dm}^{-3} \\ = 3.98 \times 10^{-8} \text{ mol dm}^{-3}$$

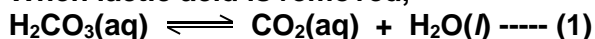
$$7.90 \times 10^{-7} = \frac{[\text{HCO}_3^-](10^{-7.40})}{[\text{H}_2\text{CO}_3]}$$

$$\frac{[\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3]} = \frac{7.90 \times 10^{-7}}{3.98 \times 10^{-8}} = 19.8$$

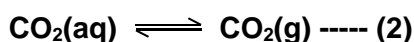
The ratio is high as HCO_3^- is needed to remove lactic acid in the blood during heavy exercises.

- (iv) Using the information given, explain, with the aid of two equations, how the production of lactic acid leads to the increase in rate of breathing. [2]

When lactic acid is removed,

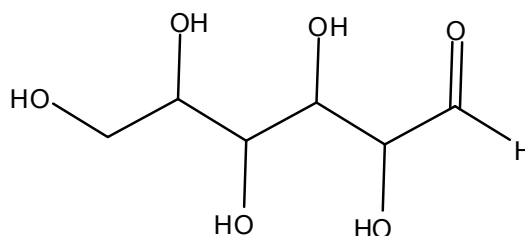


When $[\text{H}_2\text{CO}_3]$ increases, the equilibrium position in (1) shifts right. Thus, more $\text{CO}_2(\text{aq})$ is formed.



When $[\text{CO}_2(\text{aq})]$ increases, the equilibrium position in (2) shifts right, forming more $\text{CO}_2(\text{g})$ and thus the rate of breathing increases.

- (b) Lactic acid is converted to *glucose* via gluconeogenesis in the liver.



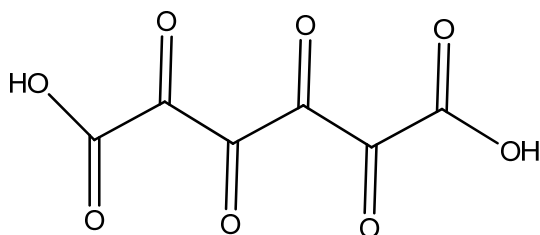
Glucose

- (i) Name the functional group(s) present in glucose. [2]

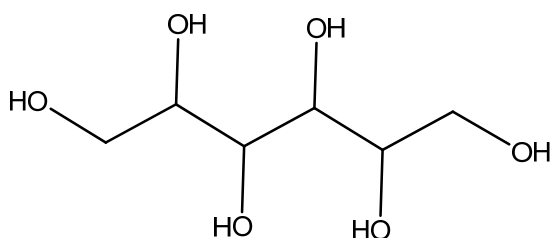
Aldehyde, primary alcohol and secondary alcohol

- (ii) Draw the skeletal formula of the organic products when *glucose* is added to [2]

(l) H_2SO_4 (aq), K_2CrO_7 , heat



(II) LiAlH_4 , dry ether, reflux



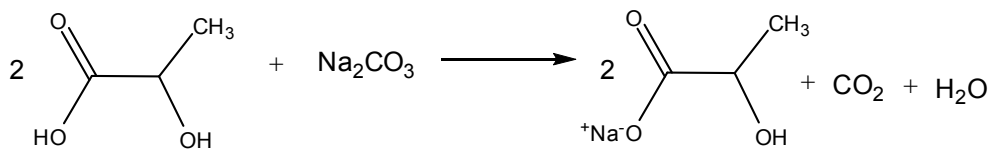
- (iii) Describe a simple chemical test that you could use to distinguish between lactic acid and glucose. You are to include reagents and conditions, observations and balanced equation(s) in each case. [3]

r/c: Na_2CO_3 (aq)

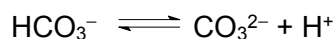
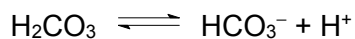
Observation:

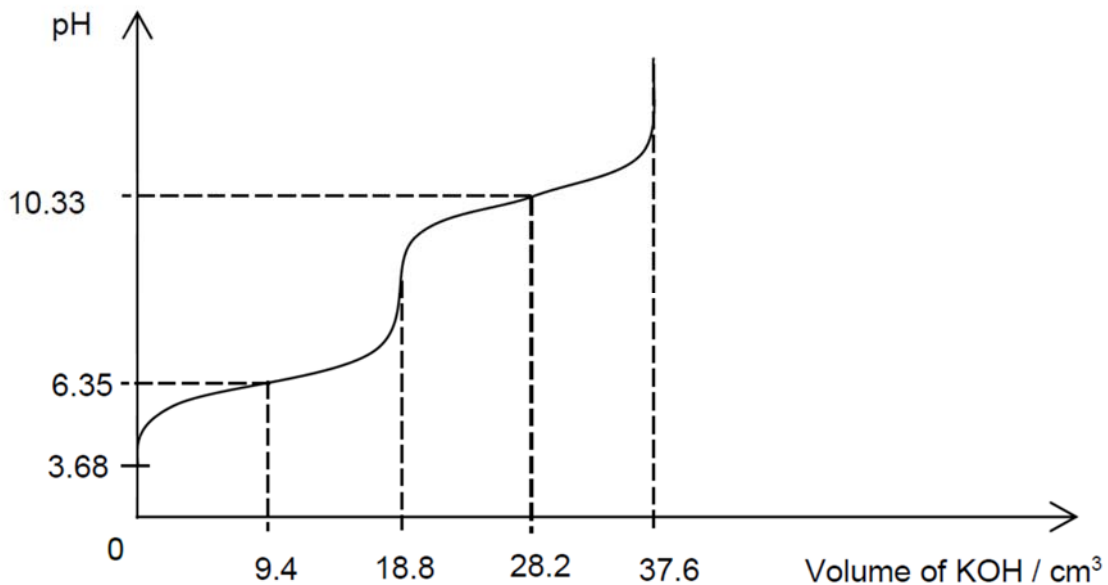
Lactic acid- effervescence observed. colourless odourless gas gives white ppt in limewater.

Glucose. No effervescence observed. No white ppt formed in limewater.



- (c) In an experiment, 25 cm^3 of $0.100 \text{ mol dm}^{-3} \text{ H}_2\text{CO}_3$ is titrated with aqueous potassium hydroxide. The titration curve is shown below. The acid dissociation of H_2CO_3 is as shown in the following equations.





- (i) Justify that carbonic acid, H_2CO_3 , is a weak acid with relevant calculations. [2]

**Initial $[\text{H}^+(\text{aq})] = 10^{-3.68} = 2.09 \times 10^{-4} \text{ mol dm}^{-3} < 0.100 \text{ mol dm}^{-3}$
 H_2CO_3 is partially/ weakly dissociated. Hence, H_2CO_3 is a weak acid.**

- (ii) Calculate the concentration of KOH, in mol dm^{-3} , used in the titration. [1]

$[\text{KOH}] = 25/18.8 \times 0.100 = 0.133 \text{ mol dm}^{-3}$

- (iii) Suggest, with a reason, a suitable indicator for the first end point of this titration. [2]

Phenolphthalein OR thymol blue as the first equivalence point lies within the working range of the indicator of pH 8-10.

[Total: 20]