VICTORIA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 1 **ANSWERS**

CANDIDATE NAME .....

CT GROUP .....

CHEMISTRY 8873/02

Paper 2 Structured Questions **29 August 2025**

Candidates answer on the Question Paper. **2 hours**

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your Name and CT group in the spaces at the top of this page.
Write in dark blue or black pen.
You may use a HB pencil for any diagrams or graphs.
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.

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

For Examiner's Use		
Section A	1	/ 11
	2	/ 20
	3	/ 9
	4	/ 7
	5	/ 13
Section B	6 / 7	/ 20
Total		/ 80

This document consists of **17** printed pages and **1** blank page.

Section A

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

1 **(a)** The element sodium can exist as a number of isotopes.

Complete the Table 1.1 for two isotopes species of sodium.

Isotopic species	protons	neutrons	electrons	electronic configuration
$^{23}_{11}Na$	11	12	11	$1s^2 2s^2 2p^6 3s^1$
$^{24}_{11}Na^+$	11	13	10	$1s^2 2s^2 2p^6$

- 1 mark for correct cation
- 1 mark for correct number of protons, neutrons and electrons
- 2 marks. 1 mark for each correct electronic configuration (ecf)

[4]

(b) Sodium oxide, Na_2O and sodium peroxide, Na_2O_2 are two compounds that can be produced when sodium metal is heated in oxygen under suitable conditions.

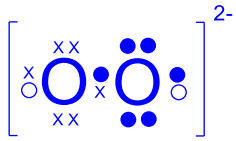
Both Na_2O and Na_2O_2 are ionic compounds. Each compound contains only **one** single anion and the charge on each anion is the same.

(i) Write the formulae of the anions in Na_2O and Na_2O_2.

- O^{2-} in K_2O and O_2^{2-} in K_2O_2

[1]

(ii) Draw a 'dot-and-cross' diagram of the anion in Na_2O_2, showing the outer shell electrons only.

- 

[1]

(iii) Predict the relative magnitudes of the melting points of Na_2O and Na_2O_2. Explain your answer.

L.E. $\propto \frac{q^+q^-}{r^+ + r^-}$

- Both O^{2-} and O_2^{2-} are **doubly charged / same charge** and O^{2-} is **smaller** in size than O_2^{2-}.
- Hence, Na_2O has a **larger** magnitude of lattice energy than that of Na_2O_2 [or **stronger** ionic bonds / electrostatic forces of attraction in Na_2O]. Melting point of Na_2O is **higher** than that of Na_2O_2.

[2]

(c) **(i)** When the Group 1 cation, $\mathbf{M^+}$, is passed through an electric field, it is deflected through an angle of +5.0°.

The angle of deflection is dependent on the relative masses and charge of the particles as shown.

$$\text{Angle of deflection} \propto \frac{\text{charge}}{\text{mass}}$$

Given that the same electric field deflected $^{92}Sr^{3+}$ through an angle of +22°, calculate the relative atomic mass (A_r) of **M**. Hence suggest a possible identity of the **M**.

Angle of deflection ∝ k |charge/mass|

For Sr^{3+},

22 = k |3/92|

- k = 675

For unknown Group 1 cation,

5.0 = 675 |1/A_r|

A_r = 135

- Hence the Group 1 metal is likely to be caesium.

[2]

(ii) Explain why the second ionisation energy of **M** is more endothermic than its first ionisation energy.

- The second electron is removed from an inner shell, which is closer and more strongly attracted to the nucleus. More energy is needed to remove the second electron, and second ionisation energy is more endothermic.

[1]

[Total:11]

2 Nitrogen is a vital element for sustaining life on Earth. Despite its high abundance in the atmosphere, the availability of reactive nitrogen compounds for biological and industrial use was historically limited. The development of the Haber process for the synthesis of ammonia, followed by the Ostwald process for the large-scale production of nitric acid from ammonia, in the early 20th century marked a significant breakthrough in expanding the availability of reactive nitrogen species for agricultural and industrial applications.

(a) Ammonia is manufactured from nitrogen and hydrogen by the Haber process as shown in the equation:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta H_{rxn} = -92 \text{ kJ mol}^{-1}$$

Under certain conditions, the system reached dynamic equilibrium with the following gas concentrations.

gas	concentration / mol dm^{-3}
nitrogen	1.36
hydrogen	1.84
ammonia	0.142

(i) Explain what is meant by dynamic equilibrium.

- Dynamic equilibrium exists in a reversible reaction in a closed system in which the rates of the forward and backward reactions are equal, resulting in no net change in the concentrations of the reactants and products.

[1]

(ii) Write an expression for the equilibrium constant, K_c, for the Haber process.

- $K_c = \frac{[NH_3]^2}{[N_2][H_2]^3}$

[1]

(iii) Calculate the value of K_c given the following equilibrium concentrations and state the units of K_c.

$K_c = \frac{(0.142)^2}{(0.136)(1.84)^3}$

- $= 2.38 \times 10^{-3}$
- for correct units $mol^{-2}\ dm^6$

[2]

(iv) Suggest a reason why the activation energy for the Haber process is high.

- The activation energy of the process is high due to the high bond energy of the N≡N bond.

[1]

(v) Describe and explain the conditions required for the favourable production of ammonia in Haber process.

- **High pressure** (200 atm) favours the production of ammonia. By Le Chatelier's Principle, the **equilibrium position will shift right** to reduce the increase in pressure leading to greater amount of ammonia.
- **Low temperature** favours the production of ammonia. By Le Chatelier's Principle, the **equilibrium position will shift right** to produce more heat leading to greater amount of ammonia. However low temperature will mean **slower rate of reaction**. Hence temperature is **kept high** (450 °C) for **faster rate of reaction.**
- **Addition of catalyst** (finely divided iron) is used to increase the rate of reaction but not the yield of ammonia.
- **Continuous removal of NH_3** as it forms shifts the position of equilibrium to the right, thereby favour the production of NH_3.

Total 4 marks. Max 3 marks

[3]

(b) A large proportion of the ammonia manufactured is then used to manufacture nitric acid, which is another industrially important compound. In the chemical industry, synthesis of nitric acid (HNO_3) is commonly carried out via the Ostwald process. The first stage in the process involves the catalytic oxidation of ammonia to nitric oxide (NO):

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g) \qquad \Delta H = -905\ kJ\ mol^{-1}$$

(i) Explain, in terms of bonds, why the enthalpy change of the reaction is exothermic.

- The **energy absorbed to break bonds** is **less than the energy released in forming bonds.**

[1]

(ii) Using relevant bond energies in the *Data Booklet* and the given value of enthalpy change for the reaction, determine the N=O bond energy in nitric oxide.

- $\Delta H = \sum$B.E. (reactants) – $\sum$B.E. (products)
  –905 = 12 (B.E. N–H) + 5 (B.E O=O) – [4 (B.E. N=O) + 12 (B.E O–H]]
- –905 = 12(390) + 5(496) – 4(B.E. N=O) – 12(460)
  –905 = 7160 – 4(B.E. N=O) – 5520
  –905 = 1640 – 4(B.E. N=O)
  4(B.E. N=O) = 2545
- B.E (N=O) = +636.25
  = +636 kJ mol (3 s.f)

[3]

(iii) Explain, in terms of frequency of collisions, the effect of increasing the concentration of the reactants on the rate of oxidation of ammonia.

- An increase in concentration of reactants means the **number of gaseous particles per unit volume increases**. Number of collisions per unit time increases. **Frequency of effective collisions increases,**
- resulting in an **increase in rate of oxidation of ammonia.**

[2]

(c) A student investigated the reaction between hydrogen gas and nitric oxide.

$$2H_2(g) + 2NO(g) \rightarrow 2H_2O(g) + N_2(g)$$

The following data were obtained.

experiment	initial concentration of $H_2(g)$/ mol dm^{-3}	initial concentration of $NO(g)$/ mol dm^{-3}	initial rate/ mol dm^{-3} h^{-1}
1	1.20×10^{-3}	1.60×10^{-3}	8.00×10^{-4}
2	1.20×10^{-3}	3.20×10^{-3}	3.20×10^{-3}
3	3.60×10^{-3}	1.60×10^{-3}	2.40×10^{-3}

(i) Deduce the orders of reaction with respect to NO and H_2.

- Comparing experiments 1 and 2:

  when initial [NO] was doubled, ($\frac{3.20 \times 10^{-3}}{1.60 \times 10^{-3}}$ = 2) with initial [H_2] constant,

  the initial rate was increased by 4 times: ($\frac{3.20 \times 10^{-3}}{8.00 \times 10^{-4}}$ = 4)

  Therefore, order of reaction with respect to NO = **2**

- Comparing experiments 1 and 3:

  when initial [H_2] was tripled, ($\frac{3.60 \times 10^{-3}}{1.20 \times 10^{-3}}$ = 3) with initial [NO] constant,

  the initial rate was tripled: ($\frac{2.40 \times 10^{-3}}{8.00 \times 10^{-4}}$ = 3)

  Therefore, order of reaction with respect to H_2 = **1**

[2]

(ii) Hence, write the rate equation for the reaction.

- rate = $k[NO]^2[H_2]$

[1]

(iii) Use the data from Experiment 1 to calculate a value for the rate constant.

$8.00 \times 10^{-4} = k\,(1.60 \times 10^{-3})^2(1.20 \times 10^{-3})$

$$k = \frac{8.00 \times 10^{-4}}{(1.20 \times 10^{-3})(1.60 \times 10^{-3})^2}$$

- = **260 000** (3 s.f.)

[1]

(d) An enzyme which was recently discovered was found to catalyse the reduction of nitrite ion, NO_2^-, to nitric oxide, NO.

(i) Write the half-equation for the reduction of nitrite ion, NO_2^-, to nitric oxide, NO.

- $NO_2^- + 2H^+ + e^- \rightarrow NO + H_2O$

  or
- $NO_2^- + H_2O + e^- \rightarrow NO + 2OH^-$

[1]

(ii) However, it was also found that the same enzyme is unable to reduce nitrate ions, NO_3^-, to nitric oxide. Suggest an explanation for this.

- The enzyme is **highly specific** and binds to nitrite ion only.

[1]

[Total: 20]

3 **(a)** Baking powder, which is used in cooking, contains sodium hydrogencarbonate, $NaHCO_3$. It decomposes on heating according to the equation as shown.

$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$

(i) A sample of baking powder contains 30 % by mass of sodium hydrogencarbonate. What volume of carbon dioxide, measured at room temperature and pressure, would be produced by the total decomposition of the sodium hydrogencarbonate in 7.0 g of the baking powder?

- Mass of $NaHCO_3$ in 7.0 g of baking powder = $\frac{30}{100} \times 7.0 = 2.1$ g

  Number of moles of $NaHCO_3$ = $\frac{2.1}{23.0+1.0+12.0+3(16.0)}$ = 0.0288 mol

- Number of moles of CO_2 = ½ x 0.0288 = 0.0144 mol
- Volume of CO_2 at r.t.p = 0.0144 x 24 = 0.345 dm^3

[3]

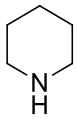
(ii) After consuming food or drink containing sugar, the pH in the mouth will decrease as the sugar is broken down into lactic acid. In time, hydrogencarbonate ions in saliva restore the pH into its original value.

Write an ionic equation to show how hydrogencarbonate ions decrease the acidity.

- $HCO_3^- + H^+ \rightarrow CO_2 + H_2O$

[1]

(b) Piperidine is a monoacidic base and is widely used building block and chemical reagent in the synthesis of organic compounds.



piperidine

(i) The pH of an aqueous solution of piperidine is 10.1. Calculate the concentration of hydroxide ions in the solution.

pOH = 14 – 10.1 = 3.9
$[OH^-] = 10^{-3.9}$

- $= 1.26 \times 10^{-4}$ mol dm^{-3}

[1]

(ii) In a titration, 25 cm^3 of the aqueous solution of piperidine in **(b)(i)** was found to react completely with 30 cm^3 of 0.15 mol dm^{-3} of HCl(aq). Calculate the concentration of piperidine solution.

$C_{piperidine}V_{piperidine} = C_{HCl}V_{HCl}$
$C_{piperidine}(25/1000) = (30/1000)(0.15)$

- $C_{piperidine} = 0.180$ mol dm^{-3}

[1]

(iii) With reference to your answers to **(b)(i)** and **(b)(ii)**, explain why piperidine is a weak base.

- **$[OH^-]$ is much lower** than piperidine concentration and hence piperidine **did not undergo complete dissociation** to give OH^-. Thus it is a weak base.

[1]

(iv) Which of the indicators from the table below could you use for this titration in **(b)(ii)**?

Indicator	Working range	Low pH colour	High pH colour
Tetrabromophenol blue	3.0 – 4.6	yellow	blue
Thymolphthalein	9.3 –10.5	colourless	blue

Explain your answer.

- Tetrabromophenol blue.
- It is a strong acid-weak base titration (equivalence point pH <7) and the working range of the indicator falls within the range of rapid pH change of the titration curve.

[2]

[Total:9]

4 Titanium dioxide (TiO_2) nanomaterials are being investigated for use in photocatalytic systems. When light is shone onto these materials, reactive species are generated. These reactive species could be applied to water and air purification systems.

One such form of titanium dioxide is nanorods, which have dimensions of 10 nm by 50 nm by 110 nm.

(a) (i) Explain why titanium dioxide nanorods cannot be classified as nanoparticles.

- Titanium dioxide nanorods have **one dimension which exceeds 100 nm/only two of the dimensions are less than 100 nm.**

[1]

(ii) Titanium dioxide in its normal, non-nanosized form is known as *bulk* titanium dioxide. Suggest why titanium dioxide nanorods exhibit much better catalytic properties than bulk titanium dioxide.

- Titanium dioxide nanorods **have a much higher surface area to volume ratio** than bulk titanium dioxide.

[1]

(b) Briefly describe one negative impact associated with the use of nanomaterials and nanoparticles in daily life.

- Inhalation/swallowing of nanoparticles could **cause health issues** such as asthma OR when released into the environment, **they could pollute water/air.**

(accept any reasonable health/environmental impact associated with nanomaterials)

[1]

(c) Graphene is commonly used in flexible electronic devices such as wearable sensors and foldable displays. These electronic devices can be folded flexibly while still being powered by electrical energy. Their lithium-ion batteries are commonly enhanced by a coating of graphene to improve flexibility and durability.

Explain, in terms of structure and bonding:

(i) why graphene has high electrical conductivity;

- In graphene, each carbon atom is **bonded to three other carbon atoms. The fourth electron is found inside a p orbital.**
- p orbitals on adjacent carbon atoms **overlap to form a continuous π electron cloud, allowing electrons to delocalise** and move to conduct electricity.

[2]

(ii) why graphene is resistant to breaking when pulled or stretched.

- The C–C covalent bonds in graphene are **strong and require large amounts of energy to break**, which gives graphene high tensile strength.

[1]

(iii) Phosphorene has a structure analogous to graphene. The 3D view of a layer of phosphorene is shown in Fig. 4.1.

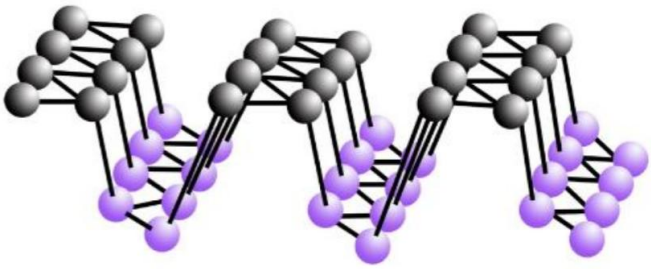


Fig 4.1

With reference to the structures of graphene and phosphorene, suggest why graphene is preferred over phosphorene in the production of ultra-thin electronic devices.

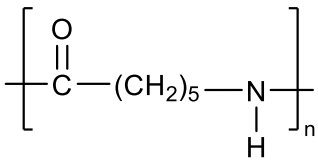
- **A layer of graphene is flat**, thus layers of graphene **occupy much less space when stacked** than **layers of phosphorene, which are not flat.**

[1]

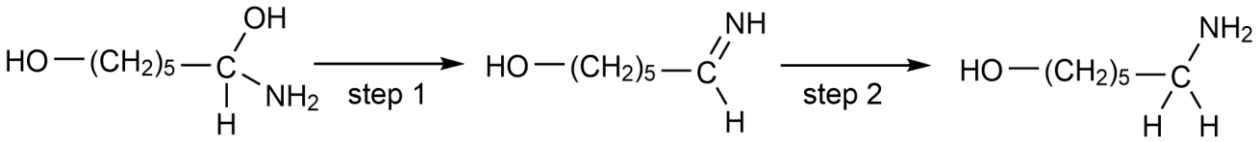
[Total: 7]

5 Nylon–6 was one of the earliest synthetic polymers developed for commercial use. Today, it is still used to manufacture items such as womens' stockings.

The structure of nylon–6 is shown below:



Compound **A**, which can be converted to the monomer of nylon–6, is synthesised via the following pathway:



intermediate 1 compound **A**

(a) Name the two functional groups present in compound **A**.

- **amine**
- **primary alcohol**

[2]

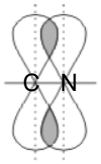
(b) (i) Suggest the type of reaction taking place in:

- step 1: **elimination**
- step 2: **reduction** [2]

(ii) Hence, suggest the reagent(s) and conditions for step 2.

- **H_2 gas, Ni catalyst with heat, or Pt catalyst OR $NaBH_4$ OR LiA/H_4 in dry ether** [1]

(c) Describe, in terms of orbital overlap, the formation of the π bond in C=N double bond of intermediate 1. Illustrate your answer with a diagram.

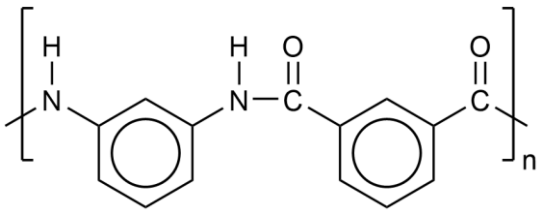


[2]

- a **π – bond,** which is formed by **side – on overlap of p orbitals** from C and N.

(d) Nomex® is another polymer that shares the same type of linkage as nylon–6. However, unlike nylon–6, it is synthesised from two different monomers.

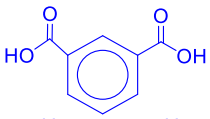
The structure of Nomex® is given below.

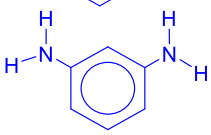


(i) Name the type of linkage that is found in both Nomex® and nylon–6.

- **amide linkage** [1]

(ii) Suggest the structures of the two monomers used to synthesise Nomex®.

- 

- 

[2]

(iii) Fibres of Nomex® and nylon–6 were separately stretched until the fibres tore. The force required to induce tearing of both polymers were measured and recorded.

Suggest the polymer which required a greater force to induce tearing and explain your answer with reference to the structure of the polymer you have chosen.

- Nomex® required a greater force to induce tearing.
- This is due **to the presence of benzene rings** which leads to **restricted rotation of bonds.** This prevents the polymer chain from easily sliding past each other when force is applied, causing Nomex® to be more rigid/higher tensile strength than nylon–6

- The presence of **delocalised electrons in benzene ring** in Nomex® also allow for **stronger intermolecular forces of attractions** between the polymer chain.

[3]

[Total: 13]

Section B

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

6 **(a)** Aluminium, silicon and phosphorus are elements in the third period of the Periodic Table. Arrange the elements in order of increasing melting point. Explain your answer in terms of structure and bonding.

- Si has the highest melting point as it has a **giant covalent structure**, and **strong covalent bonds between atoms**
- A*l* has a **giant metallic lattice** with metallic bonds / electrostatic **attraction between the delocalised electrons and cations.**
- P exists as **simple covalent P_4 molecules** with weak **instantaneous dipole – induced dipole interactions between the molecules.**
- **More energy** is required to overcome the covalent bonds between Si atoms than the metallic bonds of Mg, while **least energy** is required for the dispersion forces between P molecules. Melting point **increases in the order P < A*l* < Si.**

[4]

(b) There is said to be a 'diagonal relationship' between beryllium and aluminium. This refers to similarities in chemical properties between both elements due to their similar electronegativities, and because their ions have similar charge densities.

(i) When a few drops of water are added to solid beryllium chloride ($BeCl_2$) , steamy white fumes of hydrogen chloride are evolved and a white solid remains, which is insoluble in water.

Suggest the identity of the white solid.

- **beryllium oxide/beryllium hydroxide** [1]

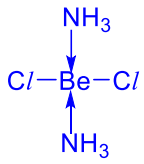
(ii) Hence, write the balanced chemical equation for the reaction between solid beryllium chloride and a small amount of water.

- $BeCl_2(s) + H_2O(l) \rightarrow BeO(s) + 2HCl(g)$ [1]

[OR $BeCl_2(s) + 2H_2O(l) \rightarrow Be(OH)_2(s) + 2HCl(g)$]

(iii) Under suitable conditions, ammonia reacts with beryllium chloride via the formation of dative bonds.

Describe how a dative bond is formed between a molecule of ammonia and a molecule of beryllium chloride. Hence suggest the structural formula of the product formed when beryllium chloride reacts with ammonia.

- The **lone pair of electrons** on N atom Is donated into **an empty orbital on the Be atom.**
- Structural formula is $BeCl_2(NH_3)_2$ or 

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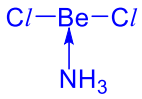


- Can also accept $BeCl_2(NH_3)$ or

[2]

(iv) At 550 °C, beryllium chloride vapour exists as a mixture of $BeCl_2$ and species **Y**, which has a relative molecular mass of 160. **Y** also contains dative bonds.

Given that the relative molecular mass of the gaseous mixture at 550 °C is 100, determine the percentages of $BeCl_2$ and **Y** in the gaseous mixture.

Let x be fraction of $BeCl_2$
And (1 – x) be fraction of **Y**

$100 = 80x + 160(1 – x)$
$x = 0.75$ and $1 – x = 0.25$

- Composition is 75% $BeCl_2$ and 25% Y.

[1]

(c) Silane, SiH_4, can be produced via the reaction of solid magnesium silicide (Mg_2Si) with dilute hydrochloric acid, as shown in the following equation:

$$Mg_2Si(s) + 4HCl(aq) \rightarrow SiH_4(g) + 2MgCl_2(aq)$$

(i) State and explain whether the silane molecule is polar.

- The molecule is **non-polar** as there is **no net dipole moment**/Si – H bonds are **arranged symmetrically/in a tetrahedral shape so that dipole moments cancel out.**

[1]

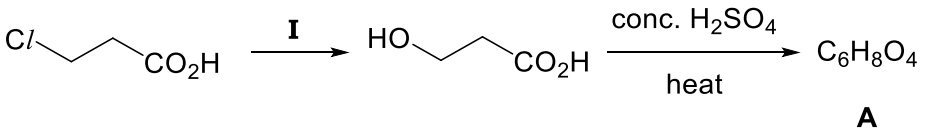
(ii) Silane gas can be liquefied either by applying high pressure at room temperature or by lowering the temperature at normal pressure.

Explain this phenomenon in terms of intermolecular forces.
The liquefaction of gases takes place when the **intermolecular forces of attraction become so high/ so significant** that gas particles are held so close together that they condense into a liquid.

- At **high pressure**, the **molecules come closer together** and thus, the intermolecular forces of attraction becomes more significant.
- By **lowering the temperature**, the **kinetic energy of the molecules decreases** and with that, the intermolecular forces of attraction becomes more significant.

[2]

(d) A series of reactions starting from 3-chloropropan-1-ol is shown.



(i) State the type of reaction occurring at reaction **I**.

- Substitution.

[1]

(ii) State the reagents and conditions required for reaction **I**.

- NaOH(aq), heat followed by addition of dilute acid

[1]

(iii) **A** is an 8-membered cyclic compound. Suggest the role of concentrated sulfuric acid, conc. H_2SO_4, in this reaction and state the type of reaction that has occurred.

- Catalyst / dehydrating agent (do not accept drying agent)
- Condensation (do not accept elimination)

[2]

(e) An organic acid contains 41% carbon, 5% hydrogen and 54% oxygen by mass.

0.090 moles of the acid reacts exactly with 0.18 moles of ethylamine, in the presence of DCC, to produce 0.090 moles of an amide.

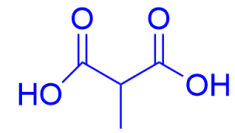
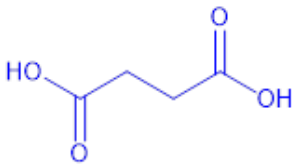
(i) Calculate the molecular formula of the acid.

	carbon	hydrogen	oxygen
mass/g	41	5	54
molar mass/ g mol^{-1}	12.0	1.0	16.0
amount/mol	41/12.0 = 3.42	5/1.0 = 5	54/16.0 = 3.38
simplest ratio	3.42/3.38 = 1.01	5/3.38 = 1.48	3.38/3.38 = 1

- Thus, empirical formula = $C_2H_3O_2$
- From the given data, the compound contains 2 -COOH groups. However, if there are only 2 -COOH groups, the molecular formula would be $H_2C_2O_4$ (which doesn't match). Thus, molecular formula of the acid is $C_4H_6O_4$.

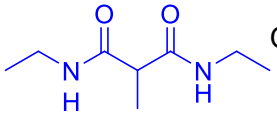
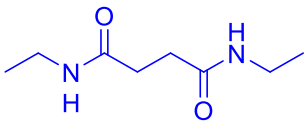
[2]

(ii) Suggest the structure of the organic acid.

-  OR 

[1]

(ii) Suggest the structure of the amide.

-  OR 

[1]

[Total: 20]

7 **(a)** Describe the reactions, if any, of the oxides Na_2O, Al_2O_3 and P_4O_{10} with water. Write an equation for any reaction and state the pH of the resultant mixtures.

- Na_2O **reacts vigorously with water and dissolves** to form a colourless and strongly alkaline solution of **pH 13.**
  $Na_2O(s) + H_2O(l) \rightarrow 2NaOH(aq)$
- Al_2O_3 is **insoluble in water** (OR does not react with water), **pH = 7.**
- P_4O_{10} **reacts vigorously with water** and **dissolves to form a colourless and acidic solution of pH 2.**
  $P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H_3PO_4(aq)$

[3]

(b) Sodium is a commercially important alkali metal.

(i) Explain why sodium metal is typically stored under kerosene oil.

- This prevents the reactive sodium from **reacting with/coming into contact with air/oxygen/water**.

[1]

(ii) Using relevant data from the *Data Booklet*, compare and explain the reducing power of sodium and potassium.

- The first ionisation energy of Na is greater than K.
  K: 418 kJ mol^{-1}
  Na: 494 kJ mol^{-1}
- The valence electrons are further away from the nucleus and hence more easily removed due to the weaker attraction to the nucleus. It becomes **easier to remove an electron from the atom from K than Na,** thus ease of oxidation increases.
- Reducing power of potassium is greater than that of sodium.

[3]

(c) Alloys of aluminium and magnesium are often used in the aircraft manufacture because of their high strength and low density.

A 1.50 g sample of one such alloy was reacted with an excess of aqueous sodium hydroxide. Only aluminium reacted, and 1.50 dm^3 of hydrogen gas was produced at room temperature and pressure.

(i) The aluminium containing product of this reaction is the same as that from the reaction between aluminium oxide and sodium hydroxide. Based on this information, write the equation for the reaction between aluminium and sodium hydroxide.

- $2Al + 2OH^- + 6H_2O \rightarrow 2[Al(OH)_4]^- + 3H_2$

[1]

(ii) Calculate the percentage by mass of aluminium in the sample of alloy.

If you did not get the equation in **(c)(i),** then assume 1 mole of aluminium reacts to give 2 moles of hydrogen. This is **not** the correct stoichiometry.

Amount of $H_2 = \frac{1.50}{24} = 0.0625$ mol

- Amount of $Al = \frac{2}{3} \times 0.0625 = 0.0417$ mol

Mass of $Al = 0.0417 \times 27.0 = 1.13$ g

- % by mass of $Al = \frac{1.13}{1.50} \times 100\% =$ **75.3%**

[2]

(d) (i) Define the term *standard enthalpy change of combustion*, $\Delta H_c^{\ominus}$, using liquid propanone, CH_3COCH_3, as an example.

Illustrate your answer with a balanced equation, including state symbols.

- Standard enthalpy change of combustion (ΔH_c°) of propanone is the energy released when **one mole of propanone** is **completely burnt in oxygen under standard conditions (of 1 bar and 298K).**
- **CH_3COCH_3 (l) + $4O_2$(g) → $3CO_2$(g) + $3H_2O$(g)**

[2]

(ii) When 0.980 g of liquid propanone was combusted using a spirit lamp, the temperature of 100 cm^3 of water increased from 25.0 ºC to 68.3 ºC.

The transfer of the heat evolved in the reaction to the water was only 65 % efficient.

Calculate the enthalpy change of combustion of propanone.

heat absorbed = (100)(4.18)(68.3 – 25.0) = 18099 J

- heat released from combustion = 18099 x 100/65 = 27845 J

amount of propanone = $\frac{0.980}{58.0}$ = 0.0169 mol

- enthalpy change of combustion = $\frac{-27845}{0.0169}$ = -1.65×10^6 J mol^{-1}
  = **-1650 kJ mol^{-1}** [2]

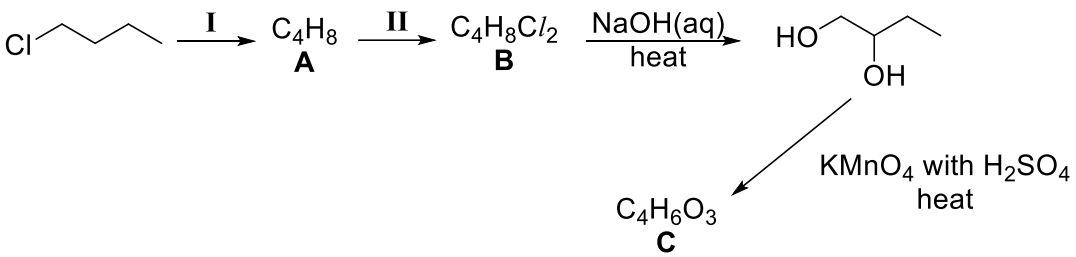
(iii) The literature value for the standard enthalpy change of combustion of propanone is -1790 kJ mol^{-1}.

Suggest why the value calculated in **(d)(ii)** is less exothermic than the literature value, even though the efficiency of heat transfer to the water was taken into account.

- Combustion was **not performed under standard conditions** (e.g: insufficient oxygen so the combustion was incomplete).

[1]

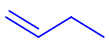
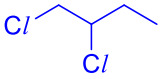
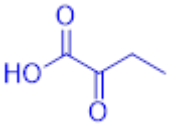
(e) A series of reactions starting from 1-chlorobutane is shown.



(i) State the reagents and conditions required for reactions **I** and **II**.

- reaction **I**: NaOH in ethanol, heat
- reaction **II**: Cl_2 or Br_2 (in the dark, room temperature) [2]

(ii) Draw the structural formulae of **A, B** and **C.**

A	**B**	**C** ($C_3H_4O_2$)
		

- 1 mark for each compound

[3]

[Total: 20]