**Secondary Four Chemistry**
**Preliminary Examination 2024**
**Mark Scheme**

**Paper 1**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| B | B | D | B | C | C | D | C | C | C |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| B | B | D | A | D | B | D | D | A | D |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| C | C | B | A | C | C | D | C | B | B |
| 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| C | A | C | C | D | C | C | C | A | D |

**Paper 2**

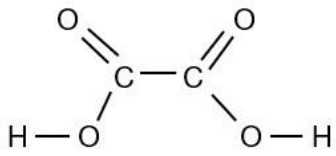
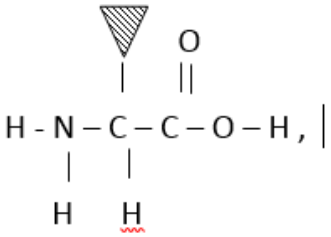
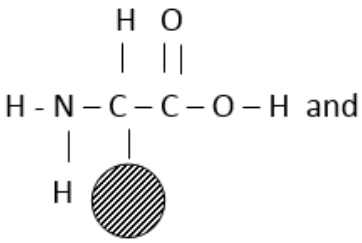
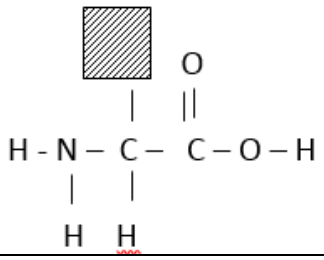
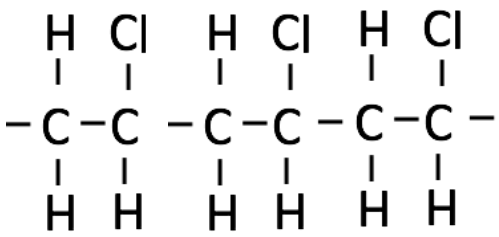
**Section A**

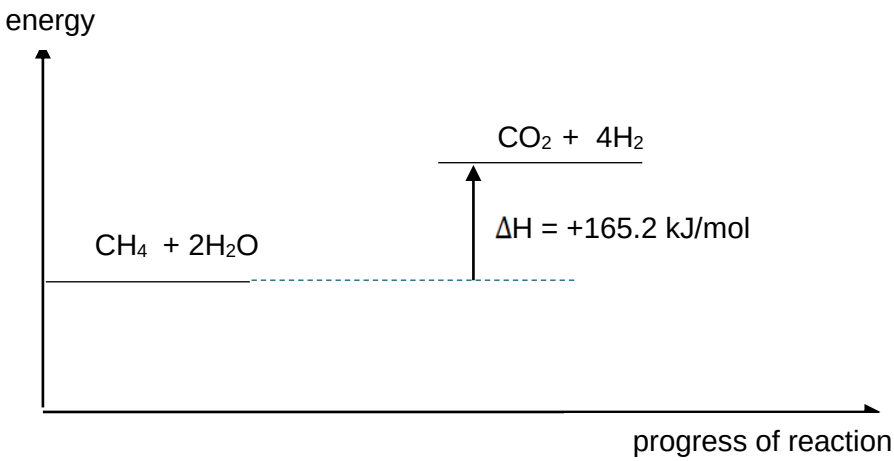
| Qn No. | Answer | Mark |
|---|---|---|
| **1a** | **A** | 1 |
| **b** | **D** (Accept E: $GeCl_4$ bp: 86.5$^oC$ ) | 1 |
| **c** | **B** | 1 |
| **d** | **C** | 1 |
| **e** | **G** | 1 |
| | **Total** | **5** |
| | | |
| **2a** | **Water vapour** produced escaped from the tube **OR**<br>**Water** was removed through evaporation**.** | 1 |
| **b** | To ensure that reaction is complete/ no more water (vapour) was produced. | 1 |
| **c** | Energy taken in = (2.00 ÷ 238)× 88.1<br>= 0.740336134 kJ<br>= 0.740 kJ | 1<br><br><br>1 |
| **d** | Endothermic/thermal decomposition | 1 |
| | **Total** | **5** |
| | | |

| Qn No. | Answer | Mark |
|---|---|---|
| **3a** | half equation(s) in each beaker<br>Difference stated<br><br>In beaker A, the anode would **decrease in size/becomes smaller** as copper is a reactive electrode and dissolves to form copper(II) ions.<br>$Cu(s) \rightarrow Cu^{2+}(aq) + 2e$<br><br>In beaker B, there is **no change in size** for anode. $OH^-$ ions are preferentially discharged to form oxygen gas.<br>$4OH^-(aq) \rightarrow 2H_2O(l) + O_2(g) + 4e^-$<br><br>**OR**<br>There is **no effervescence** in beaker A as copper is a reactive electrode and dissolves to form copper(II) ions.<br>$Cu(s) \rightarrow Cu^{2+}(aq) + 2e$<br><br>In beaker B, there is **effervescence** observed at the anode. $OH^-$ ions are preferentially discharged to form oxygen gas.<br>$4OH^-(aq) \rightarrow 2H_2O(l) + O_2(g) + 4e$ | 1<br>1 |
| **bi** | Number of moles of electrons = 289500 ÷ 96500<br>= 3 moles | 1 |
| **ii** | $Cu^{2+}(aq) + 2e \rightarrow Cu(s)$<br>No of moles of electrons = 3 moles<br>No of moles of Cu= 1.5 moles<br>Mass of Cu produced in both beakers = 1.5 x 64 g/mol<br>= 96g | <br><br>1<br><br>1 |
| **d** | Universal Indicator will turn from **green to violet**.<br>Hydrogen ions are preferentially discharged to form hydrogen gas, concentration of $OH^-$ more than that of $H^+$, **solution becomes alkaline/pH of solution increases.** | 1<br><br>1 |
| | **Total** | **7** |
| | | |
| **4a** | Carbon monoxide produced/chlorine used is toxic/poisonous. | 1 |
| **b** | Argon is unreactive/inert.<br>It prevents oxygen/water vapour in the air from reacting with sodium used /titanium produced. | 1<br>1 |
| **c** | Titanium chloride is a metal chloride which is usually an **ionic compound**. Ionic compounds **have high melting points** and are **solids** at room temperature. | 1<br>1 |

| Qn No. | Answer | Mark |
|---|---|---|
| **d** | $TiCl_4 + 4\ Na \longrightarrow Ti + 4\ NaCl$<br>From eqn,<br>1 mol $TiCl_4$ reacts with 4 mol Na<br>190 g $TiCl_4$ reacts with 92 g Na<br>**190 kg $TiCl_4$ reacts with 92 kg Na**<br>40 kg $TiCl_4$ reacts with (40÷190) x 92 kg<br>= **19.4 kg Na**<br>**$TiCl_4$ is the limiting reactant** since 40 kg of $TiCl_4$ reacts completely with 19.4 kg of Na but 20 kg of Na is available. | <br><br><br><br>1<br><br>1<br>1 |
| **e** | Actual mass = (92.3 ÷ 100) × 13.5 kg<br>= 12.5 kg | 1 |
| | **Total** | **9** |
| | | |
| **5a** | Magnesium (most reactive), chromium, iron, nickel (least reactive)<br>Magnesium oxide is **not reduced by carbon at a high temperature** (1750 °C) because it is a very **stable oxide**. This shows that magnesium is the **most reactive metal**, forming the most stable oxide.<br>Nickel(II) oxide is **reduced at the lowest temperature** (above 300 °C) because it is the **least stable oxide**. This shows that nickel is the **least reactive metal**, forming the least stable oxide. | 1<br>1<br>1 |
| **b** | Any two characteristic properties of iron, highlighting its difference from potassium.<br>Iron has **high melting and boiling points** whereas potassium has **low melting and boiling points**.<br>Iron is **hard** whereas potassium is **soft**.<br>Iron forms **compounds** which are **coloured** whereas compounds of potassium are usually **not coloured/white**.<br>Iron has **variable oxidation states** in its compounds but not potassium. | 2 |
| **ci** | Add **aqueous sodium hydroxide/ammonia** to a sample of iron(II) chloride solution a little at a time and then in excess.<br>A **green precipitate** is formed, which is **insoluble in excess**, showing that iron(II) ions are present. | 1<br>1 |
| **ii** | $Fe_2Cl_6$ | 1 |
| | **Total** | **8** |

<table>
<tr><th>Qn No.</th><th>Answer</th><th>Mark</th></tr>
<tr><td>6a</td><td>Energy absorbed = [(5 x 413) + 347 + 358 + 467] + [(3 x 495)]<br>= 4722 kJ<br>Energy released = [(4 x 799) + (6 x 467)] = 5998 kJ<br>Overall energy change = 4722 + [–5998] kJ<br>= –1276 kJ<br>= –1280 kJ</td><td>1<br>1<br><br><br>1</td></tr>
<tr><td>b</td><td>The reaction is exothermc because energy released when bonds are formed in 2 moles carbon dioxide and 3 moles of water is greater than energy absorbed when bonds are broken in 1 mole of ethanol and 3 moles of oxygen.</td><td>1<br>1<br>1</td></tr>
<tr><td></td><td>Total</td><td>6</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>7a</td><td>Both immediate and long-term impact are acceptable answers.<br><u>Immediate impact</u>: Milk bottle made of glass has a greater impact on the environment because it uses more energy to process the raw materials for glass (6750 kJ) than for polymer (1710 kJ)<br><u>Long-term impact</u>: Milk bottle made of polymer is used only once while a milk bottle made of glass is used 25 times during its lifetime. Hence it has a greater impact on the environment because it would use more energy (1710 kJ x 25) to process the raw materials than a glass bottle (6750 kJ).</td><td><br>1<br>1</td></tr>
<tr><td>b</td><td>Advantage – it can be reused up to 25 times<br>Disadvantage – it is heavier so it takes more energy to transport</td><td>1<br>1</td></tr>
<tr><td>c</td><td>Recycling of polymer conserves crude oil which reduces pollution/reduces the need to extract crude oil.</td><td>1</td></tr>
<tr><td></td><td>Total</td><td>5</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>8a</td><td>$C_{12}H_{26} \rightarrow C_2H_4 + C_{10}H_{22}$</td><td>1</td></tr>
<tr><td>b</td><td><table><tr><th></th><th>C</th><th>H</th><th>O</th></tr><tr><td>Mass (g)</td><td>1.44</td><td>0.36</td><td>0.96</td></tr><tr><td>Molar mass (g/mol)</td><td>12</td><td>1</td><td>16</td></tr><tr><td>Number of moles</td><td>1.44 ÷12<br>= 0.12</td><td>0.36 ÷ 1<br>= 0.36</td><td>0.96 ÷ 16<br>= 0.06</td></tr><tr><td>Simplest mole ratio</td><td>0.12 ÷ 0.06<br>= 2</td><td>0.36 ÷ 0.06<br>= 6</td><td>0.06 ÷ 0.06<br>= 1</td></tr></table>$C_2H_6O$</td><td>1<br>1</td></tr>
<tr><td>c</td><td>Hydration<br>Ethanol</td><td>1<br>1</td></tr>
<tr><td>di</td><td>Purple acidified potassium manganate(VII) turns colourless.<br>Ethane-1,2-diol is a reducing agent.</td><td>1<br>1</td></tr>
</table>

| Qn No. | Answer | Mark |
|---|---|---|
| ii |  | 1 |
| | **Total** | **8** |
| | | |
| 9ai | Any 2 of the 3<br>  <br>  <br>  | 2 |
| ii | chromatography | 1 |
| b |  | |

| Qn No. | Answer | Mark |
|---|---|---|
| **c** | In the manufacture of proteins, the different **monomers join together with the elimination of water** but in the formation of polymer **N**, the **monomers join together without loss of any small molecules.** | 1 |
| | **Total** | **5** |
| | | |
| **10a** |  <br>energy level<br>reactants and products<br>enthalphy | <br><br>1<br>1<br>1 |
| **b** | $N_2 + 3\ H_2 \rightleftharpoons 2\ NH_3$<br>The lower the temperature, the higher the yield of ammonia | 1<br>1 |
| **c** | The production of hydrogen in the **steam-methane reforming reaction** produces **carbon dioxide**, which is a greenhouse gas.<br>OR<br>The steam-methane reforming reaction requires a **high temperature** of 800°C – 900°C, likely from the burning of fossil fuels which produces **carbon dioxide, a greenhouse gas.** | 1<br>1 |
| **d** | Electricity from solar/geothermal/wind/nuclear energy. | 1 |
| **ei** | It requires a lower pressure to maintain ammonia which has a higher boiling point in the liquid state at room temperature compared to hydrogen.<br>It requires less energy to lower the temperature to the boiling point of ammonia which is higher than that of hydrogen. | 1 |
| **ii** | It is expensive to have high pressure tanks to store and transport hydrogen gas. | 1 |
| **f** | Nitrogen and water.<br>Combustion of ammonia does not produce carbon dioxide/carbon monoxide | 1<br>1 |
| | **Total** | **12** |

## Section B

| Qn No. | Answer | Mark |
|---|---|---|
| **11a** | As the **colour intensity of the solution increases** from chlorine to bromine to iodine/the **darker the colour of the solution**, the **higher the absorbance reading** on the colorimeter. | 1 |
| **b** | $Cl_2(aq) + 2\ KI\ (aq) \rightarrow 2KCl\ (aq) + I_2\ (aq)$ | 1 |
| | Chlorine is **more reactive than iodine**, it displaces iodine from potassium iodide. | 1 |
| | From 0 to 5 $cm^3$, the **absorbance reading increases from 0.00 to 0.34 and remains constant from** 5 $cm^3$ onwards. | 1 |
| | As iodine is being produced, **concentration of iodine increases, the solution becomes darker a**nd the absorbance reading increases. | 1 |
| | At 5 $cm^3$, **all of the chlorine is used up / reacted** and KI is in excess and concentration of iodine does not increase. | 1 |
| **c** | 0.025 mmol/$dm^3$ | 1 |
| | The 8 $cm^3$ potassium iodide added may not be in excess at this concentration of chlorine. | 1 |
| **d** | From Graph 2, Concentration of chlorine = 0.0125 mmol/$dm^3$ | |
| | Mass of chlorine in 1 $dm^3$ = 0.0125 x (35.5x2) = 0.0120 x 71 = 0.8875 mg = <u>0.888 mg</u> (3sf) | 1 |
| | Hence, the swimming pool water contains lower than the desired range of chlorine and does not meet the sanitation requirement. | 1 |
| | **Total** | **10** |
| | | |
| **12a** | **Sulfur** produced is a **precipitate/is insoluble**. | 2 |
| **b** | Stop light from other sources reaching the sensor | 1 |
| **ci** | Decreasing curve starting at (0,95) | |
| | Steeper initially than curve for 0.10 mol/$dm^3$ sodium thiosulfate solution levelling at 24% | 1 |
| **ii** | Draw tangent to the curve at 30 seconds. | 1 |
| **d** | From **0 to 20 seconds**, the **rate of reaction** is the **highest** because the **concentration of reactants is greatest** at the start. | 1 |
| | **After 20 seconds**, the **reaction slows down** because the **reactants are used up.** | 1 |
| | **At 80 seconds**, the **reaction stops** because all the dilute hydrochloric **acid is used up.** | 1 |
| | When the concentration of sodium thiosulfate solution increases to 0.20 mol/$dm^3$, there are **more particles per unit volume**. The **frequency of effective collision between sodium thiosulfate and hydrochloric acid particles increases**. This increases the rate of reaction. | 1<br>1 |
| | **Total** | **10** |