**Answers to Section A:**

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

**Section A**

| | | |
|---|---|---|
| 1(a) | Graphite | 1 |
| (b) | Zinc | 1 |
| (c) | Copper | 1 |
| (d)(i) | Ammonia and nitric acid | 1 |
| (d)(ii) | $NH_4NO_3$ | 1 |
| 2(a) | $SO_2 + \frac{1}{2} O_2 \rightarrow SO_3$<br>Or<br><br>$2SO_2 + O_2 \rightarrow 2SO_3$ | 1 |
| (b) | Vanadium(V) oxide/ $V_2O_5$<br><br>Vanadium(V) oxide is used to react with sulfur dioxide to produce sulfur trioxide. It is then **regenerated at the end of the reaction** in stage 2. Hence this shows that vanadium(V) oxide is **not used up during the reaction**, which then shows that vanadium(V) oxide is acting as the catalyst. | 1<br><br>1 |
| (c) | Catalyst provides an **alternative pathway which has a lower activation energy**.<br><br>This results in **greater number of sulfur dioxide particles having energy greater than the activation energy**.<br><br>Hence **increasing the frequency of effective collisions**, speed of reaction will then increase.<br><br>All 3 points stated – 2m<br>2 points stated – 1m<br><br>Not accepted: Rate of effective collisions / more effective collisions | 2 |
| (d) | Sulfur dioxide **can react with the oxygen in the air and dissolved in rainwater to form acid rain**, which can **destroy aquatic life and plants/ corrodes metal structures and limestone buildings.**. | 1 |
| 3(a) | $CH_4$/ methane<br><br>It has the **smallest relative molecular mass (16),** hence the rate of diffusion is the fastest. | 1<br><br>1 |
| (b) | $M_r$ of $N_2$ = 28, which is the same as $M_r$ of CO.<br><br>Time taken = 132 s | 1 |

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| (c) | I agree as **temperature affects the speed/ rate of diffusion**.<br><br>Keeping the temperature constant **ensures that the rate of diffusion is only affected by/ dependent on relative molecular mass**. | 1<br><br>1 |
| (d) | Ammonia gas is **soluble** in water. / Ammonia gas can **react/ dissolve** in water. | 1 |
| 4(a)(i) | $Mg^{2+}$ (*l*) + $2e^-$ → Mg (s)<br><br>State symbols must be written. | 1 |
| (a)(ii) | Oxygen<br><br>$2O^{2-}$ (*l*) → $O_2$ (g) + $4e^-$<br><br>State symbols must be written. | 1<br><br>1 |
| (a)(iii) | Use a **glowing splint**.<br><br>The presence of oxygen will **relight/ rekindle** the glowing splint. | 1<br><br>1 |
| (b) | Mercury oxide acts as the **impurity to lower the melting point** of magnesia/ magnesium oxide. | 1 |
| (c)(i) | Isotope **are atoms of the same element** with **different number of neutrons but same number of protons.** | 1 |
| (c)(ii) | **11.01%** (exact) or **11.0%** (to 3 s.f.) | 1 |
| (c)(iii) | Average relative mass = $\frac{(78.99\times24)+(10.00\times25)+(11.01\times26)}{100}$<br>= **24.3** (to 3 s.f.)<br><br>1m for correct method.<br>1m for answer correctly left in 3 s.f. | 1<br><br>1 |
| 5(a)(i) | Percentage of ammonia drops/ decreases as temperature increases.<br><br>Or<br><br>Percentage of ammonia increases as temperature decreases. | 1 |
| (a)(ii) | Percentage of ammonia increases as pressure increases.<br><br>Or<br><br>Percentage of ammonia decreases as pressure decreases. | 1 |
| (b) | 100 °C, 1000 atm | 1 |

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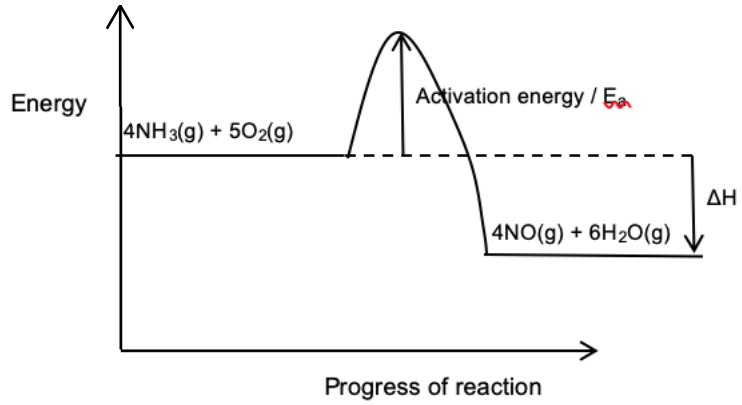
| | Units must be stated. No mark awarded for missing units. | |
| (c) | An extremely high pressure of 1000 atm is operationally **dangerous and costly**. It **may cause explosion** of the reaction vessel.<br><br>100 °C is quite a **low operating temperature**. The **speed of reaction is too slow** to produce large amount of ammonia commercially. | 1<br><br>1 |
| (d)(i) | No of moles of ammonia = $\frac{965}{24}$<br>= 40.208 mol<br><br>Mole ratio of nitric acid : ammonia = 1:1<br>No of mole of nitric acid = 40.208 mol<br>Mass of nitric acid = 40.208 (1 + 14 + 3(16))<br>= 2533.125<br>= 2530 g (3s.f.) | 1<br><br><br><br><br>1 |
| (d)(ii) | The reaction is exothermic as **the amount of energy given out to form the bonds in NO and $H_2O$ is higher**<br><br>than the **energy taken in to break the bonds in $NH_3$ and $O_2$**.<br><br>Or<br><br>The reaction is exothermic as the **amount of energy taken in to break the bonds in $NH_3$ and $O_2$ is less than**<br><br>the amount of **energy given out to form the bonds in NO and $H_2O$.**<br><br>Hence **overall, energy is given out**, and the reaction is an exothermic process. | 1<br><br>1 |
| (d)(iii) |  <br><br>1m – shape of graph<br>1m – activation energy and enthalpy change | 2 |
| 6(a) | | |

| | C | O |
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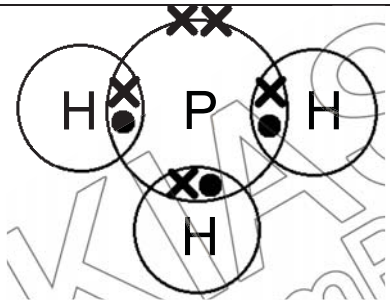
| | <table><tr><td>Mass/ g</td><td>0.92</td><td>2.43</td></tr><tr><td>No. of moles/ mol</td><td>0.92/12 = 0.076667</td><td>2.43/16 = 0.15188</td></tr><tr><td>Mole ratio</td><td>1</td><td>0.15188/0.076667<br>= 1.98 ≈ 2</td></tr><tr><td>Empirical formula</td><td colspan="2">$CO_2$</td></tr></table><br>Correct no of moles – 1 mark<br>Correct empirical formula – 1 mark | 1<br><br><br>1 |
| (b)(i) | Calcium hydroxide | 1 |
| (b)(ii) | Calcium carbonate | 1 |
| (b)(iii) | Calcium nitrate | 1 |
| (c) | $Ca^{2+}$ (aq) + $OH^-$ (aq) → $Ca(OH)_2$ (s) | 1 |
| (d) | **Heat / Evaporate to form saturated solution then cool to form crystals / crystallisation**<br><br>Then **dry** the crystals between **sheets of filter paper**. | 1<br><br>1 |
| 7(a) |  <br>Key: x – electrons of phosphorus<br>• - electrons of hydrogen<br><br>-1m for no key/ wrong size | 2 |
| (b) | Gaseous state.<br><br>Phosphane has a simple molecular structure and it has weak intermolecular forces of attraction that require little energy to overcome. | 1<br><br>1 |

**Section B**

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| 8(a) | The electron affinity decreases down the group. / Less amount of energy is given off down the group.<br><br>Reject: electron affinity becomes higher, becomes less negative/ less amount of energy given off down the group | 1 |
| (b) | Yes, I agree.<br><br>The **first electron affinity of chlorine is higher than bromine**, which shows that **the electron added to the valence shell of chlorine is held more strongly by the nucleus,**<br><br>and **gains electron more readily**, making it a stronger oxidising agent. | <br><br>1<br><br>1 |
| (c) | As the **atomic radius increases** from F to I, the **bond length increases as well from H – F to H – I. As the bond length increases, the bond strength decreases from H – F to H – I.**<br><br>Hence the **smaller the atomic radius**, the **more stable the hydrogen halide is**. **HF is the most stable** and HI is the least heat stable. | 1<br><br>1 |
| (d) | **Yes,** I agree.<br><br>**H – F has the shortest bond length** and the **highest bond energy**. This shows that **H – F is very stable**, while **H – I has the longest bond length** and **the lowest bond energy**, which shows that<br><br>it can **dissociate readily to produce hydrogen ions and iodide ions**. Hence hydrofluoric acid is the **weakest acid** and the **acid strength of hydrohalic acids increases down the group** with HI being the strongest acid.<br><br>No mark is awarded if students agree but the reasoning is wrong. | 1<br><br>1<br><br>1 |
| 9(a) | The **black CuO** will be **reduced by hydrogen gas** to form a **pink/ reddish-brown solid.**<br><br>$CuO + H_2 \rightarrow Cu + H_2O$ | 1<br><br>1 |
| (b)(i) | X, Y, Cu | 1 |
| (b)(ii) | The **change in mass for the first 5 minutes** was the greatest in boat **1**, which was 22.35 – 21.15 = **1.20 g**, followed by boat **3**, which was 22.35 – 21.20 = **1.15 g,** while for boat **2**, the mass remains **unchanged**.<br><br>This shows that **$X_2O$ were not reduced by hydrogen**. Hence it is the **most reactive metal**. Since the change in mass for the first 5 minutes was greatest for CuO than $Y_2O_3$, Y is more reactive than Cu as the **more reactive the metal is, the longer it will take to get reduced by hydrogen**. | 1<br><br>1 |

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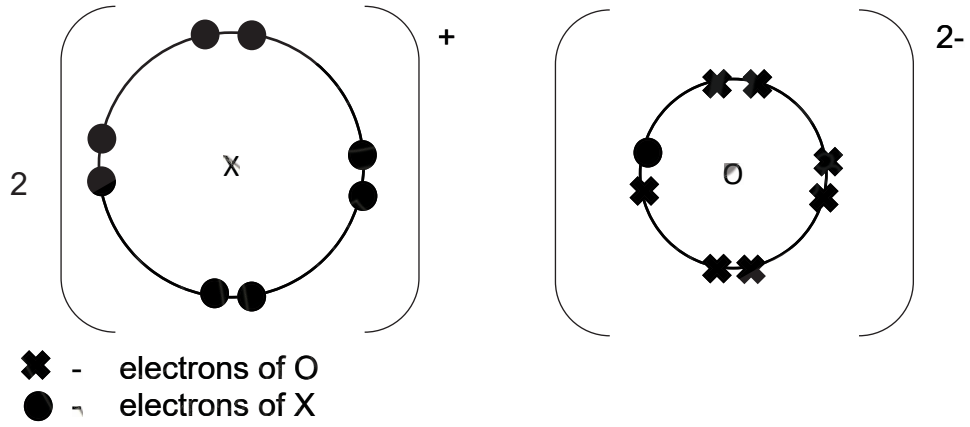
| (c)(i) | Mass of oxygen in $Y_2O_3$ = 22.35 – 20.55 = 1.80 g | 1 |
| (c)(ii) | Mass of Y = 20.55 – 16.35 = 4.20 g<br><br>Let x be the atomic mass of Y.<br>Number of moles of oxygen = 1.80/16 = 0.1125 mol<br>Number of moles of Y = 4.20/x<br>$\frac{0.1125}{3} \times 2 = \frac{4.20}{x}$<br>x = 56<br><br>Hence Y is iron/ Fe. | 1<br><br>1 |
| (d)(i) | $X_2O$ has a **giant ionic lattice structure**.<br><br>**A lot of energy** is required to **overcome the strong electrostatic forces of attraction between the oppositely charged ions**. Hence it has a high melting point.<br><br>Not accepted – break the ionic bonds/ overcome the ionic bonds | 1<br><br>1 |
| (d)(ii) |  <br>-1m for no key/ wrong size | 2 |
| E10(a) | **Oxygen is reduced as the oxidation state of oxygen/ O decreased from 0 in $O_2$ to -2 in ZnO.**<br><br>**ZnS/ sulfur in ZnS is oxidised as the oxidation state of sulfur/ S increased from -2 in ZnS to +4 in $SO_2$.**<br><br>Hence this is a redox reaction. | 1<br><br>1 |
| (b) | Process 2 does not produce carbon monoxide/ carbon dioxide.<br><br>The sulfur dioxide produced in the first step is used to make sulfuric acid and not released into the atmosphere. | 1<br><br>1 |
| (c) | $ZnO (s) + H_2SO_4 (aq) \rightarrow ZnSO_4 (aq) + H_2O (l)$<br>1m – balanced equation<br>1m – correct state symbols (provided equation is balanced) | 2 |

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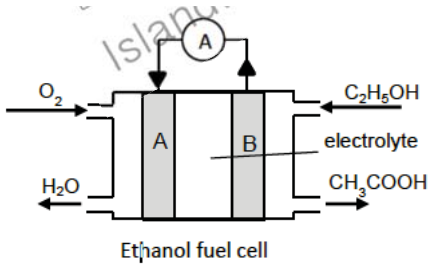
| (d)(i) | Zinc is **more reactive** than the other metals.<br><br>It **displaces** the other metals from the solution. | 1<br><br>1 |
| (d)(ii) | During electrolysis, **zinc ions and hydroxide ions are preferentially discharged** from the solution.<br><br>**Hydrogen ions and sulfate ions are left** in solution and hence forming sulfuric acid. | 1<br><br>1 |
| O10(a) | Cr in acidified potassium dichromate(VI)/ acidified potassium dichromate(VI) is reduced as the oxidation state of Cr decreases from +6 in in acidified $Cr_2O_7^{2-}$ to +3 in $Cr^{3+}$.<br><br>C in ethanol/ ethanol is oxidised as the oxidation of carbon increases from -2 in $C_2H_5OH$ to 0 in $CH_3COOH$.<br><br>Hence this is a redox reaction. | 1<br><br>1 |
| (b) | No of mole of $CH_3COOH$ in 100 $cm^3$ of blood = $0.035(\frac{100}{1000})$<br>= 0.00350 mol<br>Mole ratio of $CH_3COOH$ : $C_2H_5OH$ = 1:1<br><br>No of mole of $C_2H_5OH$ = 0.00350 mol<br><br>Mass of $C_2H_5OH$ = 0.00350[2(12)+6+16]<br>= 0.161 g<br>= 161 mg<br><br>Yes, the man will be charged with drink-driving as the 161 mg of alcohol was found in 100 $cm^3$ of blood, which exceeded the legal drink-driving limit. | 1<br><br>1<br><br>1 |
| (c)(i) |  <br>Ethanol fuel cell | 1 |
| (c)(ii) | Electrode B.<br><br>Oxidation occurs at B/ electrons are given away at B. | 1<br><br>1 |
| (c)(iii) | $C_2H_5OH + O_2 \rightarrow CH_3COOH + H_2O$ | 1 |

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| (c)(iv) | Sulfuric acid contains **mobile ions to act as the mobile charge carriers**, while **water does not have any/ has a lot lesser mobile ions** to do so. | 1 |