1)
In propene, $CH_2=CH-CH_3$,

☐ **A** the C=C double bond is longer and stronger than the C—C single bond.

☐ **B** the C=C double bond is shorter and stronger than the C—C single bond.

☐ **C** the C=C double bond is shorter and weaker than the C—C single bond.

☐ **D** the C=C double bond is longer and weaker than the C—C single bond. **1 mark)**

2)
The O—H bond in water is polar because, compared with the hydrogen atom, the oxygen atom has

☐ **A** more electrons.

☐ **B** more neutrons.

☐ **C** greater electronegativity. **1 mark)**

☐ **D** a larger atomic radius.

3)
Which of the following compounds has the highest boiling temperature?

☐ **A** CH_4

☐ **B** CH_3Cl

☐ **C** HCHO **1 mark)**

☐ **D** CH_3OH

4)
The oxidation number of sulfur in thiosulfate ions, $S_2O_3^{2-}$, is

☐ **A** +2

☐ **B** +3

☐ **C** +4 **1 mark)**

☐ **D** +6

5)
Which of the following is a redox reaction?

☐ **A** $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$

☐ **B** $MgO + H_2O \rightarrow Mg(OH)_2$

☐ **C** $NaCl + AgNO_3 \rightarrow AgCl + NaNO_3$ **1 mark)**

☐ **D** $Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O$

6)

Nickel(II) sulfate is prepared by adding an excess of nickel(II) carbonate to 0.010 mol of dilute sulfuric acid.

$$NiCO_3(s) + H_2SO_4(aq) \rightarrow NiSO_4(aq) + H_2O(l) + CO_2(g)$$

Solid nickel(II) sulfate crystals are produced with a 20% yield. How many moles of nickel(II) sulfate crystals are obtained?

☐ **A** 0.001

☐ **B** 0.002

☐ **C** 0.010 **1 mark)**

☐ **D** 0.050

7)

When 0.635 g of copper (relative atomic mass, RAM = 63.5) is added to an excess of silver nitrate solution, 2.158 g of silver (RAM = 107.9) form. The ionic equation for the reaction is

☐ **A** $Cu(s) + Ag^{2+}(aq) \rightarrow Cu^{2+}(aq) + Ag(s)$

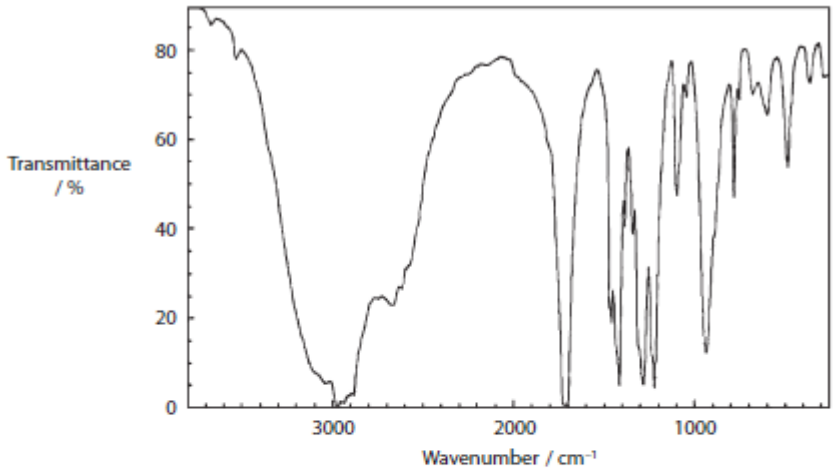
☐ **B** $Cu(s) + Ag^{+}(aq) \rightarrow Cu^{+}(aq) + Ag(s)$

☐ **C** $2Cu(s) + Ag^{2+}(aq) \rightarrow 2Cu^{+}(aq) + Ag(s)$ **1 mark)**

☐ **D** $Cu(s) + 2Ag^{+}(aq) \rightarrow Cu^{2+}(aq) + 2Ag(s)$

8)

Under certain conditions, butan-1-ol can be oxidized to the compound with infrared spectrum shown below.



O—H stretching vibrations alcohols	3750 – 3200 cm^{-1}
O—H stretching vibrations carboxylic acids	3300 – 2500 cm^{-1}
C=O stretching vibrations aldehydes and ketones	1740 – 1680 cm^{-1}
C=O stretching vibrations carboxylic acids	1725 – 1700 cm^{-1}

The compound is most likely to be

☐ **A** butan-2-ol.

☐ **B** butanal.

☐ **C** butanone. **: 1 mark)**

☐ **D** butanoic acid.

9)

Which of the following is a **secondary** alcohol?

☐ **A** 2-methylpentan-3-ol

☐ **B** 2-methylpropan-2-ol

☐ **C** 2,2-dimethylpropan-1-ol **1 mark)**

☐ **D** ethane-1,2-diol

10)

In an experiment to measure the enthalpy change of a reaction involving gases, which of the following conditions must always be kept constant?

☐ **A** Pressure

☐ **B** Temperature

☐ **C** Volume **1 mark)**

☐ **D** Temperature and pressure

11)

In an endothermic reaction in aqueous solution, which of the following is correct?

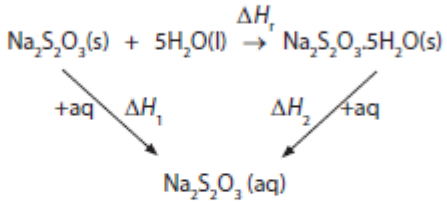
	Temperature	Sign of enthalpy change
☐ **A**	Increases	Positive
☐ **B**	Increases	Negative
☐ **C**	Decreases	Positive
☐ **D**	Decreases	Negative

1 mark)

12)

The enthalpy change for the reaction to form hydrated sodium thiosulfate crystals cannot be measured directly.

The following Hess cycle can be used.



The enthalpy change for the reaction, ΔH_r, is equal to

☐ **A** $\Delta H_1 + \Delta H_2$

☐ **B** $\Delta H_1 - \Delta H_2$

☐ **C** $-\Delta H_1 - \Delta H_2$

☐ **D** $-\Delta H_1 + \Delta H_2$ **1 mark)**

13)
This question is about the preparation of the alum, potassium aluminium sulfate, $KAl(SO_4)_2 \cdot 12H_2O$. It is a double salt consisting of potassium ions, aluminium ions and sulfate ions, and water of crystallization.

(a) The first step of the preparation involves adding an excess of aluminium foil to 10 cm^3 of 2 mol dm^{-3} potassium hydroxide to form potassium aluminate.

The equation for this reaction is

$$2Al(s) + 2KOH(aq) + 2H_2O(l) \rightarrow 2KAlO_2(aq) + 3H_2(g)$$

(i) Write a balanced **ionic** equation for this reaction.

(1)

(ii) Calculate the number of moles of potassium hydroxide used.

(1)

(iii) Hence state the number of moles of aluminium that react with the potassium hydroxide.

(1)

(iv) Use your answer to (iii) to calculate the mass of aluminium that reacts with the potassium hydroxide. Use the Periodic Table as a source of data.

(1)

(v) Calculate the total mass of aluminium added to the potassium hydroxide if a 10% excess of aluminium is required.

(1)

(vi) Identify **two** hazards in this first step of the preparation.

(2)

Hazard 1 .....

.....

Hazard 2 .....

.....

(b) The second step of the reaction is the addition of a slight excess of 1 mol dm^{-3} sulfuric acid.

(i) Balance the following equation for the reaction

(1)

$$KAlO_2(aq) + H_2SO_4(aq) \rightarrow KAl(SO_4)_2(aq) + H_2O(l)$$

(ii) Calculate the volume of the 1 mol dm^{-3} sulfuric acid that reacts with the potassium aluminate.

(1)

(iii) State how you would show that the acid had been added in excess.

(2)

*(iv) State and explain the steps necessary to obtain pure, dry crystals from the mixture.

(4)

(v) Suggest the colour of the crystals.

(1)

(vi) Suggest the formula of another metal ion which could form an alum, in combination with potassium and sulfate ions.

(1)

14)

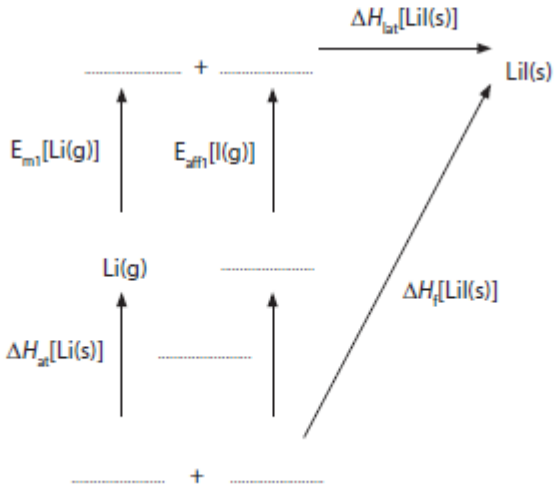
This question is about lithium iodide, an ionic salt.

(a) Draw dot and cross diagrams for the lithium and iodide ions. Show all the electrons in the lithium ion but only outer shell electrons in the iodide ion.

(2)

(b) On the Born-Haber cycle below, fill in the missing formulae (including state symbols) and the missing enthalpy change.

(3)



(c) Calculate the electron affinity of iodine, E_{aff1}[I(g)], using the data below.

	ΔH/kJ mol^{-1}
Lattice energy for lithium iodide, ΔH_{lat}	–759
Enthalpy change of atomization of lithium, ΔH_{at}	+159
Enthalpy change of atomization of iodine, ΔH_{at}	+107
First ionization energy of lithium, E_{m1}	+520
Enthalpy change of formation of lithium iodide, ΔH_f	–270

(2)

(d) The experimental lattice energy for lithium iodide is –759 kJ mol^{-1}. The theoretical lattice energy is different from this value.

Will the experimental lattice energy be more negative or less negative than the theoretical lattice energy? Justify your answer.

(3)

(e) State and explain how electron affinity values change as you go down Group 7 from chlorine to iodine.

(2)

15)

Copper(II) sulfate solution, $CuSO_4(aq)$, can be made by adding an excess of solid copper(II) oxide, CuO, to boiling dilute sulfuric acid. This is an exothermic reaction.

The balanced equation for this reaction is

$$CuO(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l)$$

(a) (i) Complete the ionic equation for this reaction, including state symbols.

(2)

$$CuO(s) +$$

(ii) Calculate the mass of copper(II) oxide needed, if a 10% excess is required, when 0.020 mol of sulfuric acid is completely reacted.

[Relative atomic masses: Cu = 63.5 and O = 16.0]

(2)

(b) (i) Suggest, with a reason, how the copper(II) oxide should be added to the boiling sulfuric acid.

(2)

(ii) When the reaction is complete, the excess copper(II) oxide is removed by filtration.

To prepare crystals of copper(II) sulfate-5-water, $CuSO_4.5H_2O$, the resulting solution is boiled to remove excess water.

How would you know when sufficient water had been removed?

(1)

(iii) After cooling the solution, crystals form. State the colour of the crystals.

(1)

(iv) The crystals all have the same shape. What does this indicate about the arrangement of the ions?

(1)

(c) (i) Calculate the molar mass of copper(II) sulfate-5-water, $CuSO_4.5H_2O$. Remember to include the appropriate units in your answer. You will need to use the Periodic Table as a source of data.

(2)

(ii) Calculate the percentage yield if 2.7 g of copper(II) sulfate-5-water is obtained from 0.020 mol of sulfuric acid.

(2)

(iii) What is the most likely reason for the yield being well below 100%?

(1)

(d) When the crystals are heated, they turn white. On adding water, they return to their original colour. Suggest a use for this reaction.

(1)

16)

Sodium hydrogencarbonate decomposes on heating to form sodium carbonate. It is difficult to measure the enthalpy change of this reaction directly.

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

One method of determining this enthalpy change is to react known amounts of sodium hydrogencarbonate and sodium carbonate, separately, with excess dilute hydrochloric acid.

(a) 0.010 mol of solid sodium hydrogencarbonate was added to 25 cm^3 of dilute hydrochloric acid. A temperature rise of 11 °C was measured using a thermometer graduated at 1 °C intervals.

(i) Calculate the heat energy produced by this reaction using the equation:

Energy transferred in joules = mass × 4.18 × change in temperature

(1)

(ii) Calculate the standard enthalpy change for the reaction when one mole of sodium hydrogencarbonate reacts with hydrochloric acid.

Remember to include a sign and units with your answer which should be given to three significant figures.

(2)

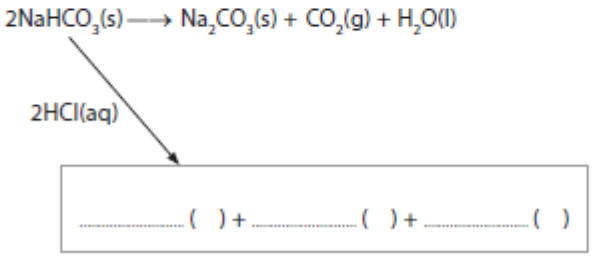
*(b) The standard enthalpy change for the reaction between sodium carbonate and dilute hydrochloric acid is found by a similar method to be

$\Delta H^{\ominus} = -321.6$ kJ mol^{-1}

Complete the Hess energy cycle below by adding the missing arrow and entities. Use it to calculate the standard enthalpy change for the decomposition of two moles of sodium hydrogencarbonate as in the equation below.

Remember to show your reasoning clearly.

(5)



(c) The uncertainty for each thermometer reading is ± 0.5 °C.
Calculate the percentage error in the temperature rise of 11 °C.

(1)

(d) Sodium hydrogencarbonate is used in cooking. Suggest what it is used for and how it works.

(2)