1   Dilute hydrochloric acid reacts with sodium carbonate solution.

$$2HCl(aq) + Na_2CO_3(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$$

(a) Explain why effervescence is seen during the reaction.

....

.... [1]

(b) Dilute hydrochloric acid was titrated with sodium carbonate solution.

- $10.0\,cm^3$ of $0.100\,mol/dm^3$ hydrochloric acid were placed in a conical flask.
- A few drops of methyl orange indicator were added to the dilute hydrochloric acid.
- The mixture was titrated with sodium carbonate solution.
- $16.2\,cm^3$ of sodium carbonate solution were required to react completely with the acid.

(i) What colour would the methyl orange indicator be in the hydrochloric acid?

.... [1]

(ii) Calculate how many moles of hydrochloric acid were used.

.... mol [1]

(iii) Use your answer to (b)(ii) and the equation for the reaction to calculate the number of moles of sodium carbonate that reacted.

.... mol [1]

(iv) Use your answer to (b)(iii) to calculate the concentration of the sodium carbonate solution in mol/dm^3.

.... mol/dm^3 [2]

(c) In another experiment, $0.020\,mol$ of sodium carbonate were reacted with excess hydrochloric acid.

Calculate the maximum volume (at r.t.p.) of carbon dioxide gas that could be made in this reaction.

.... dm^3 [3]

[Total: 9]

2 (a) Alkanes and alkenes are examples of hydrocarbons.

   (i) What is meant by the term *hydrocarbon*?

   ....

   .... [1]

   (ii) Give the general formula of straight-chain

   alkanes, ...

   alkenes. ....
   [2]

(b) A compound X contains carbon, hydrogen and oxygen only.

X contains 54.54% of carbon by mass, 9.09% of hydrogen by mass and 36.37% of oxygen by mass.

   (i) Calculate the empirical formula of compound X.

   [2]

   (ii) Compound X has a relative molecular mass of 88.

   Deduce the molecular formula of compound X.

   [2]

(c) An ester has the molecular formula $C_3H_6O_2$.

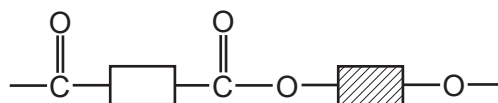Name and give the structural formulae of **two** esters with the molecular formula $C_3H_6O_2$.

name of ester		
structural formula		

[4]

(d) Name the ester produced from the reaction of propanoic acid and methanol.

.... [1]

(e) A polyester is represented by the structure shown.

   (i) What type of polymerisation is used for the production of polyesters?

.... [1]

   (ii) Which simple molecule is removed when the polyester is formed?

.... [1]

   (iii) Complete the diagrams below to show the structures of the monomers used to produce the polyester. Show all atoms and bonds.
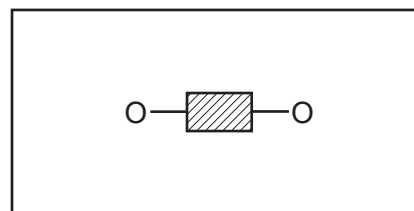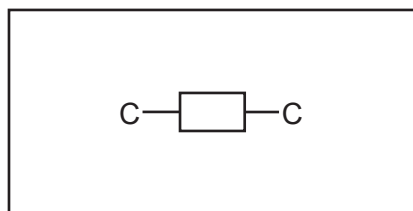
[2]

[Total: 16]

3 **(a)** A compound, **X**, contains 55.85% carbon, 6.97% hydrogen and 37.18% oxygen.

   (i) How does this prove that compound **X** contains only carbon, hydrogen and oxygen?

   .... [1]

   (ii) Use the above percentages to calculate the empirical formula of compound **X**.

   .... [2]

   (iii) The M_r of **X** is 86.

   What is its molecular formula?

   .... [2]

(b) **(i)** Bromine water changes from brown to colourless when added to **X**.

   What does this tell you about the structure of **X**?

   .... [1]

   (ii) Magnesium powder reacts with an aqueous solution of **X**. Hydrogen is evolved.

   What does this tell you about the structure of **X**?

   .... [1]
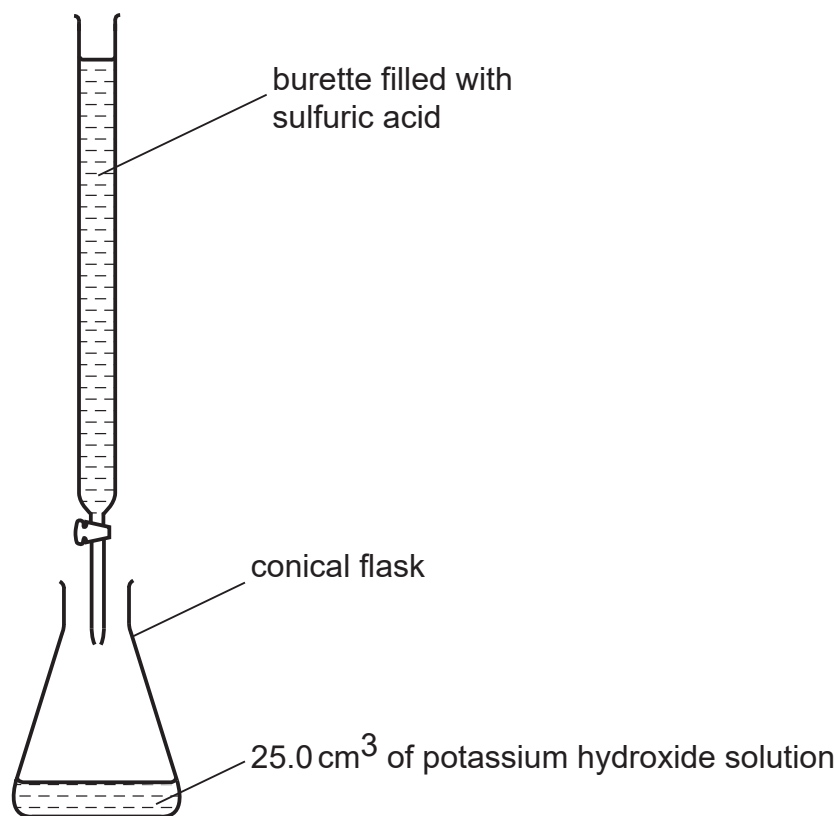
   (iii) **X** contains two different functional groups.

   Draw a structural formula of **X**.

   [1]

   [Total: 8]

4 Two salts can be made from potassium hydroxide and sulfuric acid. They are potassium sulfate, K_2SO_4, and the acid salt potassium hydrogen sulfate, $KHSO_4$. They are both made by titration.

burette filled with sulfuric acid

conical flask

25.0 cm^3 of potassium hydroxide solution

(a) 25.0 cm^3 of potassium hydroxide, concentration 2.53 mol/dm^3, was neutralised by 28.2 cm^3 of dilute sulfuric acid.

$$2KOH(aq) \ + \ H_2SO_4(aq) \ \rightarrow \ K_2SO_4(aq) \ + \ 2H_2O(l)$$ Calculate the concentration of the sulfuric acid.

number of moles of KOH used = ...

number of moles of H_2SO_4 needed to neutralise the KOH = ...

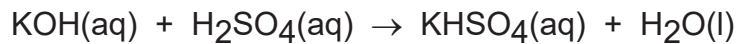concentration of dilute sulfuric acid = ... mol/dm^3

[3]

(b) In the conical flask there is a neutral solution of potassium sulfate which still contains the indicator used in the titration.

(i) Describe how you could obtain a solution of potassium sulfate without the indicator.

....

.... [2]

(ii) Potassium hydrogen sulfate can be made by the following reaction.

$$KOH(aq) + H_2SO_4(aq) \rightarrow KHSO_4(aq) + H_2O(l)$$

Suggest how you could make a solution of potassium hydrogen sulfate without using an indicator.

....

....

.... [2]

(c) Describe a test which would distinguish between aqueous solutions of potassium sulfate and sulfuric acid

test ....

result ....

[2]

[Total: 9]

5 The Atacama desert in Chile has deposits of the salt sodium nitrate. Very large amounts of this salt were exported to Europe for use as a fertiliser. After the introduction of the Haber process in 1913, this trade rapidly diminished.

(a) Explain why the introduction of the Haber process reduced the demand for sodium nitrate.

....

.... [2]

(ii) Suggest why surface deposits of sodium nitrate only occur in areas with very low rainfall such as desert areas.

.... [1]

(iii) The desert has smaller surface deposits of potassium nitrate.

Suggest why potassium nitrate is a better fertiliser than the sodium salt.

.... [1]

(b) All nitrates decompose when heated. The extent to which a nitrate decomposes is determined by the metal in the salt.

(i) Sodium nitrate decomposes to form sodium nitrite, $NaNO_2$.

Write the equation for decomposition of sodium nitrate.

.... [2]

(ii) Sodium nitrite is a reducing agent.

What would be observed if an excess of sodium nitrite solution was added to a solution of acidified potassium manganate(VII)?
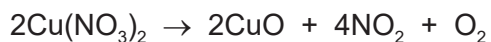
.... [2]

(iii) Copper(II) nitrate decomposes to form copper(II) oxide, nitrogen dioxide and oxygen.

What is the relationship between the extent of decomposition and the reactivity of the metal in the nitrate?

....

.... [1]

(c) The equation for the decomposition of copper(II) nitrate is given below.

$$2Cu(NO_3)_2 \rightarrow 2CuO + 4NO_2 + O_2$$

(i) Predict what you would observe when copper(II) nitrate is heated.

....

....

.... [3]

(ii) Copper(II) nitrate forms a series of hydrates with the formula $Cu(NO_3)_2.xH_2O$.
All these hydrates decompose to form copper(II) oxide.
1 mole of $Cu(NO_3)_2.xH_2O$ forms 1 mole of CuO.

What is meant by 1 mole of a substance?

....

.... [2]

(iii) 7.26 g of a hydrate, $Cu(NO_3)_2.xH_2O$, formed 2.4 g copper(II) oxide.

number of moles of CuO formed = ...

number of moles of $Cu(NO_3)_2.xH_2O$ in 7.26 g = ...

mass of 1 mole of $Cu(NO_3)_2.xH_2O$ = ... g

mass of 1 mole of $Cu(NO_3)_2$ is 188 g

the value of x in this hydrate = ...

[4]

[Total: 18]

6 Use your copy of the Periodic Table to help you answer these questions.

(a) Predict the formula of each of the following compounds.

(i) aluminium fluoride .... [1]

(ii) arsenic oxide .... [1]

(iii) silicon bromide .... [1]

(b) Deduce the formula of each of the following ions.

(i) phosphide .... [1]

(ii) barium .... [1]

(iii) francium .... [1]

(c) Draw a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound carbon dioxide.

Use x to represent an electron from a carbon atom. Use o to represent an electron from an oxygen atom.

[3]

[Total: 9]