1 Chemists use the concept of the mole to calculate the amounts of chemicals involved in a reaction.

(a) Define *mole*.

.....

[1]

(b) 3.0 g of magnesium was added to 12.0 g of ethanoic acid.

$Mg + 2CH_3COOH \rightarrow (CH_3COO)_2Mg + H_2$

The mass of one mole of Mg is 24 g.

The mass of one mole of CH_3COOH is 60 g.

(i) Which one, magnesium or ethanoic acid, is in excess? You must show your reasoning.

.....

.....

.....

[3]

(ii) How many moles of hydrogen were formed?

.....

[1]

(iii) Calculate the volume of hydrogen formed, measured at r.t.p.

.....

[2]

(c) In an experiment, 25.0 cm^3 of aqueous sodium hydroxide, 0.4 mol / dm^3, was neutralised by 20.0 cm^3 of aqueous oxalic acid, $H_2C_2O_4$.

$$2NaOH + H_2C_2O_4 \rightarrow Na_2C_2O_4 + 2H_2O$$

Calculate the concentration of the oxalic acid in mol / dm^3.

(i) Calculate the number of moles of NaOH in 25.0 cm^3 of 0.4 mol / dm^3 solution.

.....

[1]

(ii) Use your answer to **(i)** and the mole ratio in the equation to find out the number of moles of $H_2C_2O_4$ in 20 cm^3 of solution.

.....

[1]

(iii) Calculate the concentration, mol / dm^3, of the aqueous oxalic acid.

.....

[2]

2 Soluble salts can be made using a base and an acid.

(a) Complete this method of preparing dry crystals of the soluble salt cobalt(II) chloride-6-water from the insoluble base cobalt(II) carbonate.

step 1
Add an excess of cobalt(II) carbonate to hot dilute hydrochloric acid.

step 2

.....

.....

step 3

.....

.....

step 4

.....

..... [4]

(b) (i) 5.95 g of cobalt(II) carbonate were added to 40 cm^3 of hydrochloric acid, concentration 2.0 mol/dm^3.

Calculate the maximum yield of cobalt(II) chloride-6-water and show that the cobalt(II) carbonate was in excess.

$$CoCO_3 + 2HCl \rightarrow CoCl_2 + CO_2 + H_2O$$

$$CoCl_2 + 6H_2O \rightarrow CoCl_2.6H_2O$$

maximum yield:

number of moles of HCl used = ...

number of moles of $CoCl_2$ formed = ...

number of moles of $CoCl_2.6H_2O$ formed = ...

mass of one mole of $CoCl_2.6H_2O$ = 238 g

maximum yield of $CoCl_2.6H_2O$ = ... g

to show that cobalt(II) carbonate is in excess:

number of moles of HCl used = ... (use your value from above)

mass of one mole of $CoCO_3$ = 119 g

number of moles of $CoCO_3$ in 5.95 g of cobalt(II) carbonate = ... [5]

(ii) Explain how these calculations show that cobalt(II) carbonate is in excess.

..... [1]

[Total: 10]

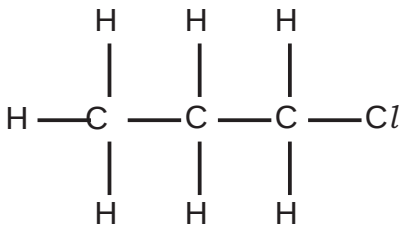
3 **(a)** Propane reacts with chlorine to form a mixture of chloropropanes. This is a photochemical reaction.

(i) What is meant by the phrase *photochemical reaction*?

.....

..... [1]

(ii) The products of this reaction include two isomers, one of which has the following structural formula.



Draw the structural formula of the other isomer.

[1]

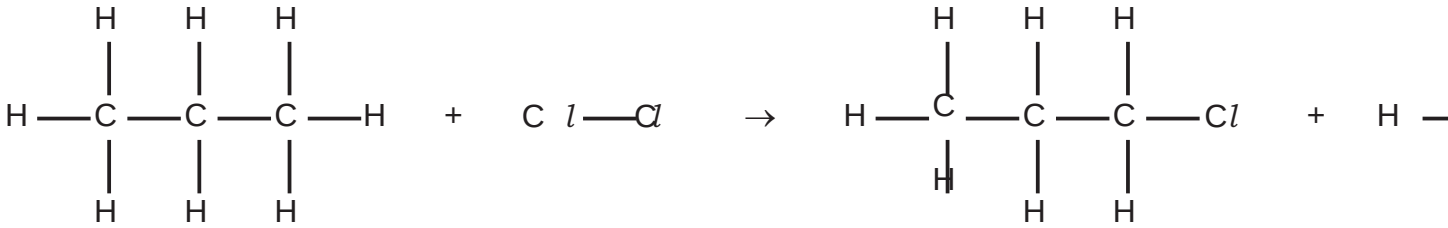
(iii) Explain why these two different compounds are isomers.

.....

..... [2]

(b) Bond breaking is an endothermic change and bond forming is an exothermic change.

Bond energy is the amount of energy in kJ/mol needed to break one mole of the specfied bond.



Use the following bond energies to determine whether this reaction is exothermic or endothermic. You must show your reasoning.

bond	bond energies in kJ/mol
C–C*l*	338
C–H	412
C*l*–C*l*	242
H–C*l*	431
C–C	348

.....

.....

.....

..... [3]

(c) Chloropropane can be hydrolysed to propanol, $CH_3CH_2CH_2OH$, by sodium hydroxide.

Write the equation for this reaction.

..... [2]

(ii) Propanol can be dehydrated. It loses a water molecule to form a hydrocarbon.

Give the name and structural formula of this hydrocarbon.

name .....

structural formula

[2]

(iii) Propanol is oxidised to a carboxylic acid by acidified potassium manganate(VII).

Deduce the name of this acid.

..... [1]

(d) Propanol reacts with methanoic acid to form the ester propyl methanoate.

$$CH_3CH_2CH_2OH + HCOOH \rightarrow HCOOCH_2CH_2CH_3 + H_2O$$ 4.0

g of methanoic acid was reacted with 6.0 g of propanol.

(i) Calculate the M_r of methanoic acid = ... [1]

(ii) Calculate the M_r of propanol = ... [1]

(iii) Determine which one is the limiting reagent. Show your reasoning.

.....

.....

..... [2]

(iv) Calculate the maximum yield in grams of propyl methanoate, M_r = 88.

..... [1]

[Total: 17]

4 Sulfuric acid is an important acid, both in the laboratory and in industry.
Sulfuric acid is manufactured in the Contact Process. Originally, it was made by heating metal sulfates and by burning a mixture of sulfur and potassium nitrate.

(a) Give a major use of sulfuric acid.

..... [1]

(b) A group of naturally occurring minerals have the formula of the type $FeSO_4.xH_2O$ where x is 1, 4, 5, 6 or 7. The most common of these minerals is iron(II) sulfate-7-water.

(i) When this mineral is heated gently it dehydrates.

$$\underset{\text{green}}{FeSO_4.7H_2O} \rightleftharpoons \underset{\text{pale yellow}}{FeSO_4} + 7H_2O$$

Describe how you could show that this reaction is reversible.

.....

.....

..... [2]

(ii) When the iron(II) sulfate is heated strongly, further decomposition occurs.

$$2FeSO_4(s) \rightarrow Fe_2O_3(s) + SO_2(g) + SO_3(g)$$

The gases formed in this reaction react with water and oxygen to form sulfuric acid.
Explain how the sulfuric acid is formed.

.....

..... [2]

(iii) A mineral of the type $FeSO_4.xH_2O$ contains 37.2% of water.
Complete the calculation to determine x.

mass of one mole of H_2O = 18 g

mass of water in 100 g of $FeSO_4.xH_2O$ = 37.2 g

number of moles of H_2O in 100 g of $FeSO_4.xH_2O$ = ...

mass of $FeSO_4$ in 100 g of $FeSO_4.xH_2O$ = ... g

mass of one mole of $FeSO_4$ = 152 g

number of moles of $FeSO_4$ in 100 g of $FeSO_4.xH_2O$ = ...

x = ...

[4]

(c) When a mixture of sulfur and potassium nitrate is burned and the products are dissolved in water, sulfuric acid is formed.

(i) The sulfuric acid formed by this method is not pure. It contains another acid.
Deduce the identity of this acid.

..... [1]

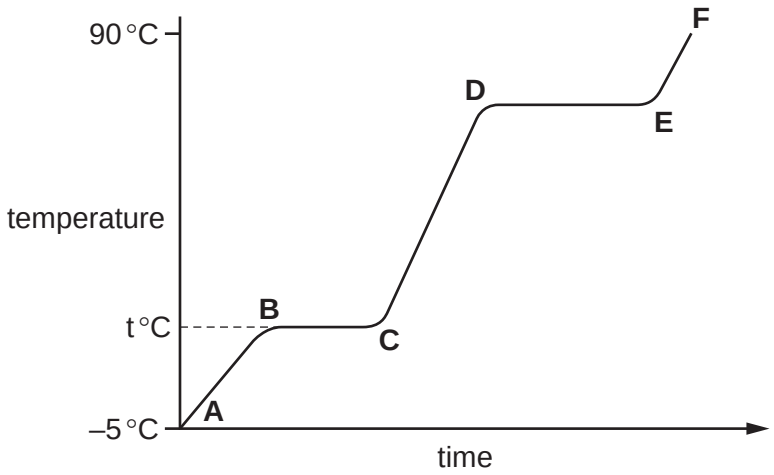
(ii) The heat causes some of the potassium nitrate to decompose.
Write the equation for the action of heat on potassium nitrate.

..... [2]

[Total: 12]

5 Compound X is a colourless liquid at room temperature.

(a) A sample of pure X was slowly heated from –5.0 °C, which is below its melting point, to 90 °C, which is above its boiling point. Its temperature is measured every minute and the results are represented on the graph.



(i) Complete the equation for the equilibrium present in the region **BC**.

X(s) ⇌ ..... [1]

(ii) What is the significance of temperature t °C?

..... [1]

(iii) What is the physical state of compound X in the region **EF**?

..... [1]

(iv) What would be the difference in the region **BC** if an impure sample of X had been used?

..... [1]

(b) Compound X is a hydrocarbon. It contains 85.7% of carbon. The mass of one mole of X is 84 g.

(i) What is the percentage of hydrogen in the compound ?

..... [1]

(ii) Calculate the empirical formula of X. Show your working.

empirical formula = ... [3]

(iii) What is the molecular formula of compound X?

..... [1]

[Total: 9]