Atoms, Amount, Equations & Reactions
AS & A Level

Question Paper 4

Level	A Level
Subject	Chemistry
Exam Board	OCR
Module	Foundations in Chemistry
Topic	Atoms, Amount, Equations & Reactions
Paper	AS & A Level
Booklet	Question Paper 4

Time allowed: **69 minutes**

Score: **/51**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E
>85%	73%	60%	47%	34%	21%

A student carries out a titration to determine the molar mass and structure of a weak acid **A**.

The student follows the method below.

- Dissolve a weighed mass of **A** in 100 cm^3 of distilled water and make the solution up to 250 cm^3 in a beaker.
- Add the solution of **A** to a burette.
- Titrate the solution of **A** with a standard solution of sodium hydroxide, NaOH.

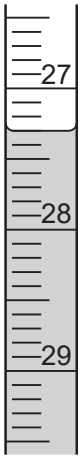
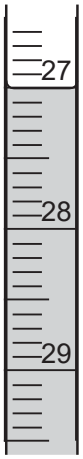
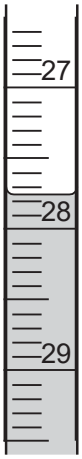
(a) What is meant by the term standard solution? **[1]**

(b) Sodium hydroxide is an alkali.

What is meant by the term alkali? **[1]**

(c) The student carries out a trial, followed by three further titrations.
The diagram shows the initial and final burette readings for the three **further** titrations.

The student measures all burette readings to the nearest 0.05 cm^3.

Titration 1		**Titration 2**		**Titration 3**	
Initial reading	Final reading	Initial reading	Final reading	Initial reading	Final reading
					

(i) Record the student's readings and the titres in the table below.

Calculate the mean titre, to the nearest 0.05 cm^3, that the student should use for analysing the results.

[4]

	Titration 1	**Titration 2**	**Titration 3**
Final reading/cm^3			
Initial reading/cm^3			
Titre/cm^3			

(ii) The uncertainty in each burette reading is ± 0.05cm^3.

Calculate the percentage uncertainty for the titre in **Titration 1**.

[1]

(iii) The student realised that the solution of **A** had not been prepared correctly.

How should the student have made up the solution?

[1]

(d) A student repeats the titration to determine the molar mass and structure of **A**.

- The student prepares a 250.0 cm^3 solution from 1.513 g of **A**.
- The solution of **A** is added to the burette and titrated with 25.0 cm^3 volumes of 0.112 $mol dm^{-3}$ NaOH(aq).
- 1 mol of **A** reacts with 2 mol of NaOH.
- The student obtains a mean titre of 27.30 cm^3.

(i) Calculate the molar mass of **A** from these results.

Give your answer to the nearest whole number.

Show your working.

[4]

(ii) **A** is an organic acid, containing C, H and O only.
One molecule of **A** contains two COOH groups.

Suggest the structure of **A**. **[1]**

(Total 13 marks)

Within the permafrost in Arctic regions of the Earth, large amounts of methane are trapped within ice as 'methane hydrate', $CH_4 \cdot xH_2O$. Methane makes up about 13.4% of the mass of 'methane hydrate'.

Scientists are concerned that global warming will melt the permafrost, releasing large quantities of methane into the atmosphere.

(a) The H–O–H bond angle in ice is about 109° but about 105° in gaseous H_2O.

Explain why there is this difference.

[3]

(b) Why are scientists concerned about the release of methane into the atmosphere?

[1]

(c) Determine the formula of 'methane hydrate', $CH_4 \cdot xH_2O$.

In the formula, show the value of x to **two** decimal places.

[2]

(d) Calculate the volume of methane, in dm^3, that would be released from the melting of each 1.00 kg of 'methane hydrate' at 101 kPa and 0 °C.

Give your answer to **three** significant figures.

[4]

(e) Suggest why some industries are interested in the presence of 'methane hydrate' in regions of the Earth.

[1]

(Total 11 marks)

Ethanoic acid, CH_3COOH, is the main dissolved acid in vinegar.

(a) Ethanoic acid is a weak acid.

What is meant by *acid* and *weak acid*?

[1]

(b) Aluminium is reacted with ethanoic acid.

(i) The unbalanced equation for the reaction is shown below.

Balance the equation.

……. $Al(s)$ + ……. $CH_3COOH(aq) \rightarrow$ ……. $(CH_3COO)_3Al(aq)$ + …… $H_2(g)$

[1]

(ii) This reaction is a redox reaction.

Deduce which element has been oxidised and which element has been reduced, and state the changes in oxidation number.

Element oxidised: ..... oxidation number change: from ..... to .....

Element reduced: ..... oxidation number change: from ..... to .....

[2]

(c) A student plans to determine the concentration, in mol dm^{-3}, of CH_3COOH in a bottle of vinegar. The student will carry out a titration with aqueous barium hydroxide, $Ba(OH)_2(aq)$.

The student's method is outlined below.

- Dilute 10.0 cm^3 of vinegar from the bottle with distilled water and make the solution up to 250.0 cm^3.
- Add the diluted vinegar to the burette.
- Titrate 25.0 cm^3 volumes of 0.0450 moldm^{-3} $Ba(OH)_2$ with the diluted vinegar.

The mean titre of the diluted vinegar is 25.45 cm^3.

The reaction in the student's titration is shown below.

$$2CH_3COOH(aq) + Ba(OH)_2(aq) \rightarrow (CH_3COO)_2Ba(aq) + 2H_2O(l)$$

(i) Calculate the concentration, in mol dm^{-3}, of CH_3COOH in the original bottle of vinegar.

Show your working. **[4]**

(ii) Suggest **one** assumption that the student has made that might mean that their calculated concentration of ethanoic acid in the vinegar is invalid.

Predict, with a reason, how the experimental result would differ from the actual concentration of CH_3COOH if the assumption were **not** correct.

[2]

(Total 10 marks)

This question is about alkenes.

(a) The combustion of ethene is shown in **equation 25.1** below.

$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(g)$ $\Delta H = -1318$ kJ mol^{-1} **equation 25.1**

(i) Explain, in terms of bond breaking and bond forming, why a reaction can be exothermic.

[1]

(ii) Average bond enthalpies are shown in the table.

Bond	Average bond enthalpy /kJ mol^{-1}
O–H	+464
O=O	+498
C–H	+413
C=O	+805

Calculate the average bond enthalpy of the C=C bond.
Use the average bond enthalpies in the table and **equation 25.1**.

[3]

(b) An alkene **D** is a liquid at room temperature and pressure but can easily be vaporised.

When vaporised, 0.1881 g of **D** produces 82.5 cm^3 of gas at 101 kPa and 373 K.

Determine the molar mass and molecular formula of alkene **D**.

Show all your working.

[5]

(Total 9 marks)

Sodium sulfide, Na_2S, is an ionic compound of sodium, Na, and sulfur, S.

(a) Draw a '*dot-and-cross*' diagram to show the bonding in sodium sulfide.

Show outer electrons only.

[2]

(b) The table below compares the properties of sodium sulfide, sodium and sulfur.

Complete the table.

		Sodium sulfide	**Sodium**	**Sulfur**
Melting point / °C		1180	98	113
Type of structure (**giant** or **simple**)				
Electrical conductivity (**good** or **poor**)	solid			
	liquid			

[3]

(c) Selenium is in the same group of the periodic table as sulfur.

(i) Complete the full electron configuration of a selenium atom.

$1s^2$ ..... **[1]**

(ii) Sodium selenide reacts with hydrochloric acid to form a toxic gas, **B**, with a relative molecular mass of 81.0.

Identify gas **B** and write an equation for this reaction.

Gas **B** .....

Equation ..... **[2]**

(Total 8 marks)