Questions are for both separate science and combined science students unless indicated in the question

Q1.

This question is about acids and their reactions.

Acids can be either weak or strong.

(a) What is meant by 'a **weak** acid'? **(HT only)**

An acid which is partially ionised in aqueous solution.

(2)

(b) Explain what happens to the pH of an acid as the acid is diluted with water.

As the acid is diluted, the concentration of hydrogen ions, H^+, decreases, so the pH increases.

conc^n = no moles / volume

(2)

(c) A student does a titration to find the volume of acid needed to neutralise an alkali.

The student fills a burette with the acid.

Give **three** more steps the student must do before adding the acid to the alkali from the burette. **(chemistry only)**

You should name any equipment used.

1 Use a volumetric pipette to add the alkali into a conical flask.

2 Add an indicator to the alkali

3 Take the initial burette reading.

(3)

(d) The student titrated a solution containing 0.0045 moles of sodium hydroxide with 0.15 mol/dm^3 hydrochloric acid.

The equation for the reaction is:

$$NaOH + HCl \rightarrow NaCl + H_2O$$
$$1 \quad : \quad 1$$

Calculate the volume of hydrochloric acid in cm^3 needed in the titration. **(chemistry only) (HT only)**

N° moles NaOH = 0.0045 = N° moles HCl = 0.0045

Conc^n = $\frac{\text{n. moles}}{\text{Volume}}$, Volume = $\frac{\text{n. moles}}{\text{Conc}^n}$ = $\frac{0.0045 \text{ mol}}{0.15 \text{ mol/dm}^3}$

Volume = 0.3 dm^3

= 0.3 × 1000 = 30 cm^3

Volume of acid = 30 cm^3

(2)

(e) A calcium atom is larger than a magnesium atom.

Explain why calcium reacts more vigorously than magnesium with hydrochloric acid of the same concentration.

Calcium's outer shell electrons are further from the nucleus, so the outer electrons are less strongly attracted to the nucleus, so positive ions are formed more easily

(3)

(Total 12 marks)

Q2.

This question is about acids and alkalis.

(a) Ethanoic acid is a weak acid.

What is meant by 'weak acid'? **(HT only)**

Answer in terms of ionisation.

The acid is only partially ionised in aqueous solution.

(1)

(b) The concentration of an acid can be measured in mol/dm^3.

Which combination of changes **increases** the concentration of an acid? **(chemistry only) (HT only)**

Tick (✓) **one** box.

The mass of acid dissolved is halved and the volume of the solution is halved.	☐
The mass of acid dissolved is halved and the volume of the solution is doubled.	☐
The mass of acid dissolved is doubled and the volume of the solution is halved.	☑
The mass of acid dissolved is doubled and the volume of the solution is doubled.	☐

(1)

(c) The concentration of an acid can be determined by titration.

An indicator is added to an alkali in a flask.

Name an indicator that can be used in this titration.

Give the colour change of the indicator when acid from a burette is added to the alkali in the flask. **(chemistry only)**

Name of indicator methyl orange

Colour change from yellow to red

(2)

(d) Sodium carbonate dissolves in water to produce an alkaline solution.

Give the formula of the ion that makes a solution alkaline.

OH^-

(1)

(e) A student does a titration using sodium carbonate solution and nitric acid.

The equation for the reaction is:

$$Na_2CO_3 + 2\ HNO_3 \rightarrow 2\ NaNO_3 + CO_2 + H_2O$$

1 : 2

25.0 cm^3 of 0.124 mol/dm^3 sodium carbonate solution is neutralised by 23.6 cm^3 of nitric acid.

Calculate the concentration of the nitric acid. **(chemistry only) (HT only)**

Give your answer to 3 significant figures.

You should calculate:
- the number of moles of sodium carbonate in 25.0 cm^3 of the solution
- the number of moles of nitric acid in 23.6 cm^3 of the nitric acid
- the concentration of the nitric acid in mol/dm^3.

$n(Na_2CO_3) = \frac{25}{1000} \times 0.124 = 3.1 \times 10^{-3}$ mol.

1 mole Na_2CO_3 reacts with 2 moles HNO_3

3.1×10^{-3} " " $2 \times 3.1 \times 10^{-3} = 6.2 \times 10^{-3}$

$[HNO_3] = \frac{\text{no. moles}}{\text{Volume } dm^3}$

Volume of HCl = 23.6 cm^3

$= \frac{23.6}{1000}\ dm^3 = 0.0236\ dm^3$

$[HNO_3] = \frac{6.2 \times 10^{-3}}{0.0236}$

$= 0.263\ mol dm^3$

Concentration (3 significant figures) = 0.263 mol/dm^3

(5)

When hydrochloric acid dissolves in water, hydrogen ions (H^+) and chloride ions (Cl^-) are produced.

(f) A solution of hydrochloric acid with pH 4.5 has a concentration of H^+ ions of 3.16×10^{-5} mol/dm^3.

What is the concentration of H^+ ions in a solution of hydrochloric acid with pH 2.5? **(HT only)**

pH, 4.5 → 2.5 decreases 2 units

[H⁺] must increase 2 orders of magnitude:

$10^{-5} \rightarrow 10^{-3}$

Concentration of H^+ ions = 3.16×10^{-3} mol/dm^3

(1)

(g) Which element has atoms that have the same electronic structure as the chloride ion?

Use the periodic table.

_____

(1)

(Total 12 marks)

Cl = Group 7

7 outer e⁻

Cl⁻ gains 1 e⁻, → Now has 8 e⁻

full shell!

(7) (0)

																	2 **He** helium 4.0
																	10 **Ne** neon 20.2
																	18 **Ar** argon 39.9
																	36 **Kr** krypton 83.8

17
9 **F** fluorine 19.0
17 **Cl** chlorine 35.5
35 **Br** bromine 79.9

Cl⁻ same

Q3.

This question is about acids and alkalis.

(a) Explain why the pH of an acid depends on: **(chemistry only) (HT only)**

- the strength of the acid
- the concentration of the acid.

pH depends on H^+ concentration

Higher the concentration of H^+, the lower the pH

Strength:

The stronger an acid, the greater the ionisation

So the stronger an acid, the lower the pH

Concentration:

The higher the concentration of an acid, the more acid in the same volume of solution.

so the higher the concentration of the acid, lower the pH. **(4)**

(b) A student titrated 25.00 cm^3 of hydrochloric acid with 0.100 mol/dm^3 barium hydroxide solution.

The table below shows the results.

Titration number	1	2	3	4	5
Volume of barium hydroxide solution used in cm^3	23.90	23.45	23.55	23.55	23.45

anomalous result

The student calculated the volume of barium hydroxide solution to be used in the titration calculation as 23.50 cm^3.

Explain why the student used a volume of 23.50 cm^3 of barium hydroxide solution in the titration calculation. **(chemistry only)**

Mean of concordant results: $\frac{23.45 + 23.55 + 23.55 + 23.45}{4}$

$= 23.50\ cm^3$

23.90 is an anomalous result.

(2)

(c) 25.00 cm^3 of the hydrochloric acid reacted with 23.50 cm^3 of the 0.100 mol/dm^3 barium hydroxide solution.

The equation for the reaction is:

$$2\ HCl(aq) + Ba(OH)_2(aq) \rightarrow BaCl_2(aq) + 2\ H_2O(l)$$

2 : 1

Calculate the concentration of the hydrochloric acid in mol/dm^3. **(chemistry only) (HT only)**

N° moles $Ba(OH)_2$ = $\frac{23.50}{1000} \times 0.100 = 2.35 \times 10^{-3}$ mol

1 mole $Ba(OH)_2$ reacts with 2 moles HCl

2.35×10^{-3} mol " " $2 \times 2.35 \times 10^{-3}$ mol

$= 4.7 \times 10^{-3}$ mol HCl

Volume of HCl = 25.00 cm^3

$= 0.025\ dm^3$

Concentration of HCl = $\frac{\text{N° mole}}{\text{Volume}} = \frac{4.7 \times 10^{-3}}{0.025} = 0.188\ mol/dm^3$

Concentration of the hydrochloric acid = 0.188 mol/dm^3

(4)

Another student titrated sulfuric acid with barium hydroxide solution.

The equation for the reaction is:

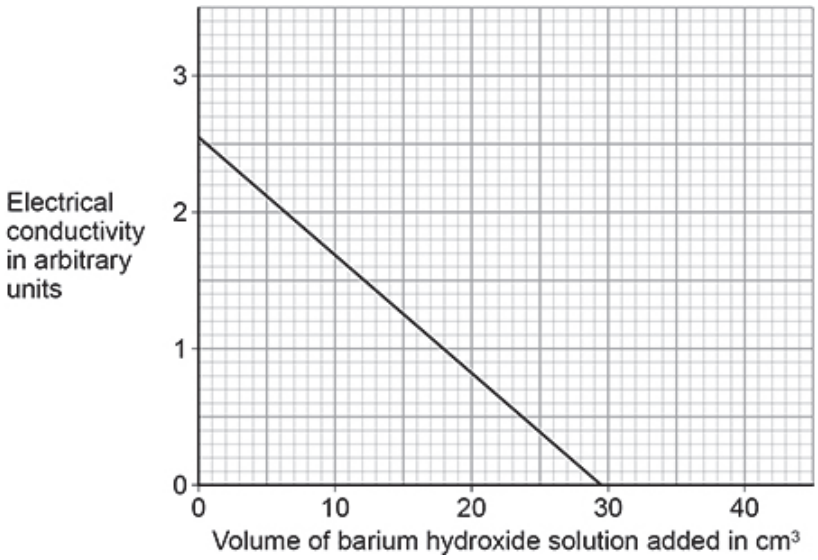
$$H_2SO_4(aq) + Ba(OH)_2(aq) \rightarrow BaSO_4(s) + 2\ H_2O(l)$$

1 : 1

The student measured the electrical conductivity of the mixture during the titration.

The better a conductor, the higher the electrical conductivity value.

The figure below shows the results.



(d) Explain why the electrical conductivity of the mixture was zero when the sulfuric acid had just been neutralised.

Use the equation for the reaction.

Refer to ions in your answer.

On neutralisation, there are no ions that are free to move, because $BaSO_{4(s)}$ is a solid. and the H^+ ions have all reacted to form H_2O

(3)

(e) The student then added a further 10 cm^3 of barium hydroxide solution.

The electrical conductivity of the mixture increased.

Give **one** reason why.

The mixture now contains Ba^{2+} ions and OH^- ions which are free to move.

(1)

(Total 14 marks)