Monitoring Chemical Reactions (H)

1. In the Haber process, nitrogen reacts with hydrogen to make ammonia.

$N_2(g) + 3H_2(g) \leftrightharpoons 2NH_3(g)$

What is the maximum volume of ammonia, NH_3, that can be made from $150cm^3$ of hydrogen, H_2?

A $50cm^3$
B $100cm^3$
C $225cm^3$
D $450cm^3$

Your answer **[1]**

2. Which is the correct expression for calculating the concentration of a solution in g / dm^3?

A $\text{Concentration} = \frac{\text{volume of solution in dm}^3}{\text{mass of solute in g}}$

B $\text{Concentration} = \frac{\text{amount of solute in mol}}{\text{mass of solute in g}}$

C $\text{Concentration} = \frac{\text{mass of solute in g}}{\text{volume of solution in cm}^3 \times 1000}$

D $\text{Concentration} = \frac{\text{mass of solute in g}}{\text{volume of solution in dm}^3}$

Your answer **[1]**

3. Chemists often have a choice of reaction pathway when making a new product.

Which factor do chemists consider when choosing a reaction pathway?

A Disposal of product
B Price they can charge for the product
C Rate of reaction
D Usefulness of waste reactants

Your answer **[1]**

4. Hydrogen gas, H_2, reacts with oxygen gas, O_2, to make water, H_2O.

$2H_2 + O_2 \rightarrow 2H_2O$

What is the **atom economy** for this reaction?

M_r: H_2 = 2, O_2 = 32, H_2O = 18

A 50%
B 53%
C 89%
D 100%

Your answer [1]

5. Which of the following is the expression used to calculate concentration in g / dm^3?

A $\text{Concentration} = \dfrac{\text{mass of solute in g}}{\text{volume of solution in dm}^3}$

B $\text{Concentration} = \dfrac{\text{mass of solvent in g}}{\text{volume of solution in dm}^3}$

C $\text{Concentration} = \text{mass of solute in g} \times \text{volume of solution in dm}^3$

D $\text{Concentration} = \dfrac{\text{mass of solute in g} \times \text{volume of solution in dm}^3}{1000}$

Your answer [1]

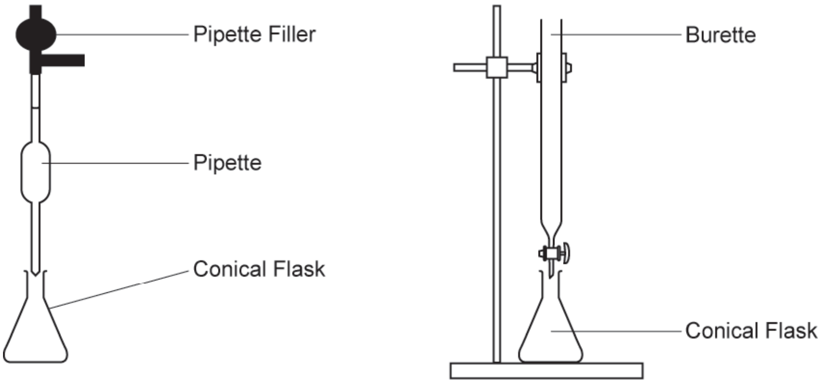
6. Which statement about **atom economy** is correct?

A A reaction that has only one product has a higher atom economy than a reaction that has two products, one of them being a waste product.
B A reaction with a low atom economy is more sustainable than a reaction with a high atom economy.
C A reaction with a low atom economy will usually produce less waste products than a reaction with a high atom economy.
D To calculate the atom economy of a reaction you need to know the expected yield and the actual yield of the products.

Your answer [1]

7 (a). A student neutralises potassium hydroxide with dilute sulfuric acid in a titration experiment.

Look at the student's method for her experiment.



- Measure 25.0 cm^3 of 0.200mol / dm^3 potassium hydroxide into a conical flask using a pipette.
- Add a few drops of universal indicator to the potassium hydroxide.
- Fill the burette to above the 0.00 cm^3 line with dilute sulfuric acid.
- Quickly add the dilute sulfuric acid to the potassium hydroxide until the indicator changes colour.
- Repeat the experiment.

Describe and explain **one** improvement the student should make to her method to get a more accurate titration result.

--- **[2]**

(b). The student repeats the experiment four times.

Look at the student's results.

Titration number	1	2	3	4
Volume of acid (cm^3)	25.75	23.60	23.70	23.65

i. Calculate the **accurate** volume of the acid that reacts with the alkali.

Accurate volume of acid = ... cm^3 **[2]**

ii. Look at the equation for the reaction between sulfuric acid and potassium hydroxide.

$H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$

Use your answer from part **(i)** to calculate the concentration of the dilute sulfuric acid, H_2SO_4, that reacted with the 25.0 cm^3 of 0.200mol / dm^3 potassium hydroxide.

Give your answer to **3** significant figures.

Concentration of dilute sulfuric acid = ... mol / dm^3 **[4]**

8(a). A student investigates the reactivity of four metals, **A**, **B**, **C** and **D**.

He adds a small piece of each metal to cold water.

He then adds a small piece of each metal to dilute hydrochloric acid.

Look at his results.

"

Metal	Observations in water	Observations in dilute hydrochloric acid
A	slow bubbling	very fast bubbling
B	no reaction	no reaction
C	fast bubbling	very fast bubbling
D	no change	slow bubbling

The piece of metal **C** used by the student produces 30 cm^3 of hydrogen gas when it reacts with the dilute hydrochloric acid at room temperature and pressure.

i. Calculate the number of **moles** of hydrogen gas produced.

One mole of any gas occupies 24 dm^3 at room temperature and pressure.

Moles of hydrogen gas = ... **[2]**

ii. Use your answer from **(i)** to calculate the **mass** of hydrogen gas produced.

Mass of hydrogen gas = ... g **[1]**

(b). Chromium metal, Cr, reacts with nickel sulfate solution, $NiSO_4$. Solid nickel is made.

Two possible equations for this reaction are:

Equation 1 $Cr + NiSO_4 \rightarrow CrSO_4 + Ni$

Equation 2 $2Cr + 3NiSO_4 \rightarrow Cr_2(SO_4)_3 + 3Ni$

10.40 g of chromium metal reacts with excess nickel sulfate solution to make 17.61 g of nickel.

Deduce which equation, **1** or **2**, represents the reaction which takes place.

A_r: Cr = 52.0, Ni = 58.7

____

____

____

____

____ **[3]**

9. Ammonium nitrate, NH_4NO_3, is a fertiliser made from ammonia.

Ammonium nitrate is made by reacting ammonia with nitric acid.

$NH_3 + HNO_3 \rightarrow NH_4NO_3$

i. Calculate the mass of **ammonium nitrate** that could be made from 25.5 tonnes of ammonia.

A_r: H = 1.0, N = 14.0, O = 16.0

Mass of ammonium nitrate = ... tonnes **[3]**

ii. A student makes some ammonium nitrate in the laboratory.

He predicts that he should make 12.5 g of ammonium nitrate.

His percentage yield is 80%.

Calculate the **actual mass** of ammonium nitrate that the student makes.

Actual mass of ammonium nitrate .... g **[2]**

10 (a). In an experiment, a mixture of ammonium chloride and calcium hydroxide is heated.

Ammonia gas, NH_3, is made.

$$2NH_4Cl + Ca(OH)_2 \rightarrow CaCl_2 + 2NH_3 + 2H_2O$$

A student adds 5.00 g of ammonium chloride to an excess of calcium hydroxide.

Calculate the maximum **volume of ammonia gas** that could be made at room temperature and pressure.

One mole of a gas occupies 24 dm^3 at room temperature and pressure.

Volume of ammonia gas = ... dm^3 **[2]**

(b). In another experiment a student reacts sodium hydroxide solution with dilute hydrochloric acid.

$$NaOH + HCl \rightarrow NaCl + H_2O$$

i. 35.0 cm^3 of 0.075 mol / dm^3 hydrochloric acid, HCl, are added to 25.0 cm^3 of 0.100 mol / dm^3 sodium hydroxide solution, NaOH.

Use the information to determine which reactant is **in excess**.

____

____

____

____

____ **[3]**

ii. To find the exact amount of dilute hydrochloric acid that reacts with 25.0 cm^3 of the sodium hydroxide solution, the student does a titration.

Look at the student's results. The rough titration is **not** shown.

	Titration 1	**Titration 2**	**Titration 3**	**Titration 4**
Final burette reading (cm^3)	36.30	38.60	39.25	38.30
Initial burette reading (cm^3)	0.00	2.80	4.05	2.10
Volume of acid used (cm^3)	36.30	35.80	35.20	36.20

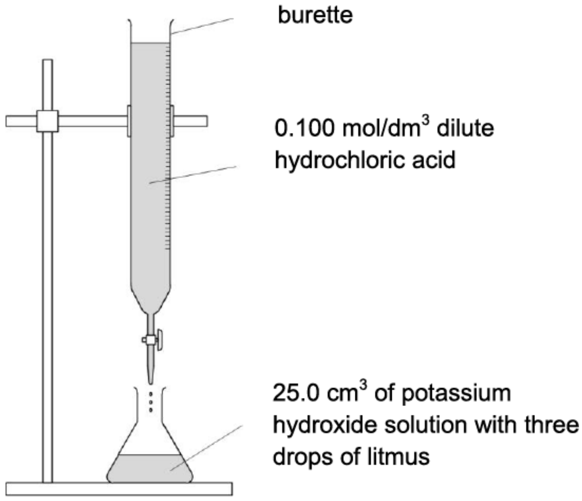
Use the student's **concordant** results to calculate the mean volume of hydrochloric acid required.

Mean volume = ... cm^3 **[2]**

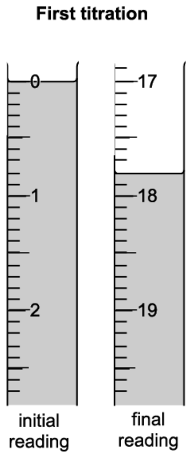
11 (a). Sarah does three titrations with dilute hydrochloric acid and potassium hydroxide solution.
Hydrochloric acid neutralises the alkali potassium hydroxide.

$$HCl(aq) + KOH(aq) \rightarrow KCl(aq) + H_2O(l)$$

Look at the apparatus she uses.



Look at the diagrams. They show parts of the burette during the first titration.



Here is Sarah's results table:

Titration number	**1**	**2**	**3**
final reading (cm^3)		37.5	32.1
initial reading (cm^3)		20.4	15.0
titre (volume of acid added) (cm_3)		17.1	17.1

Use the diagrams and table to help you calculate the mean titre.
Explain your answer.

____

____

Mean titre = ... cm^3 **[2]**

(b). Sarah uses 25.0 cm^3 of potassium hydroxide solution, KOH.

She also uses hydrochloric acid with a concentration of 0.100 mol/dm^3.

Calculate the concentration, in mol/dm^3, of the KOH(aq).

Concentration of KOH(aq) = ... mol/dm^3 **[2]**

(c). Use your answer to **(b)** to calculate the concentration of the KOH(aq) in g/dm^3.

Concentration of KOH(aq) = ... g/dm^3 **[2]**

12. Which of the following procedures is the most suitable for preparing a 0.100 mol/dm^3 solution of sodium carbonate?

The relative formula mass, M_r, of sodium carbonate is 106.

A. Dissolving 10.6 g of sodium carbonate in water to make 1.0 dm^3 of solution.
B. Dissolving 10.6 g of sodium carbonate in 0.10 dm^3 of water.
C. Dissolving 10.6 g of sodium carbonate in 1.0 dm^3 of water.
D. Dissolving 106 g of sodium carbonate in water to make 1.0 dm^3 of solution.

Your answer ☐

[1]

13. A student is making a fertiliser called potassium nitrate, KNO_3.

Look at the equation for the reaction she uses.

$$KOH + HNO_3 \rightarrow KNO_3 + H_2O$$

The relative formula masses, M_r, of each compound are shown in the table.

Compound	Formula	Relative formula mass
potassium hydroxide	KOH	56.1
nitric acid	HNO_3	63.0
potassium nitrate	KNO_3	101.1
water	H_2O	18.0

What is the atom economy for the reaction to make potassium nitrate?

Assume that water is a waste product.

A. 15.1%
B. 47.1%
C. 52.9%
D. 84.9%

Your answer ☐

[1]

14. Zinc nitrate thermally decomposes to give two gases.

$$2Zn(NO_3)_2(s) \rightarrow 2ZnO(s) + 4NO_2(g) + O_2(g)$$

A student heats 1.89 g of zinc nitrate until there is no further reaction.

What is the total volume of gas, measured at room temperature and pressure, made in this reaction?

Assume that one mole of gas occupies a volume of 24 dm^3 at room temperature and pressure.

The molar mass of zinc nitrate is 189 g/mol.

A. 0.12 dm^3
B. 0.48 dm^3
C. 0.60 dm^3
D. 1.20 dm^3

Your answer ☐

[1]

15. Urea is a fertiliser.

The formula for urea is:

$$(NH_2)_2CO$$

A student makes 1 mole of urea from 2 moles of ammonia.

What is the mass of urea that the student makes?

A. 43.0 g
B. 44.0 g
C. 58.0 g
D. 60.0 g

Your answer ☐

[1]

16. Ammonium sulfate is a salt.

It is made using the reaction between the alkali ammonia and sulfuric acid.

$$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$$

i. Describe how a sample of solid ammonium sulfate is prepared in a laboratory.

Explain why this method is not suitable to be used industrially.

____

____

____

____

____

____ **[4]**

ii. Predict the maximum mass of ammonium sulfate that can be made from 51 tonnes of ammonia.

Maximum mass = ... tonnes

17. The reversible reaction between carbon dioxide and hydrogen makes methane and water.

carbon dioxide + hydrogen ⇌ methane + water

Kayvan investigates this reaction.

He predicts that 11.0 g of carbon dioxide should make 4.0 g of methane.

In an experiment, he finds that 11.0 g of carbon dioxide makes 2.2 g of methane.

Calculate the percentage yield of methane.

____

____

____

Percentage yield = ... % **[2]**

END OF QUESTION PAPER