Monitoring Chemical Reactions

TOTAL MARKS : 24

1.

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

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

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

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

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

Your answer ☐ [1]

2.

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]

3.

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]**

4.

(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.

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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

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[3]

5.

(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]**

6.

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]

7.

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]

8.

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.

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[4]

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

Maximum mass = ... tonnes

[2]