Formulae, Equations & Amount of Substance

Question Paper

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	The Core Principles of Chemistry
Sub Topic	Formulae, Equations & Amount of Substance
Booklet	Question Paper

Time Allowed: **84 minutes**

Score: /70

Percentage: /100

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 Mohr's salt, $(NH_4)_2Fe(SO_4)_2.6H_2O$, is a blue-green crystalline solid usually made by

dissolving equimolar amounts of iron(II) sulfate and ammonium sulfate in dilute sulfuric acid and then crystallising.

The reaction may be represented by the equation

$$FeSO_4.7H_2O + (NH_4)_2SO_4 \rightarrow (NH_4)_2Fe(SO_4)_2.6H_2O + H_2O$$

| Molar masses /g mol^{-1} | 278 | 132 | 392 | 18 |
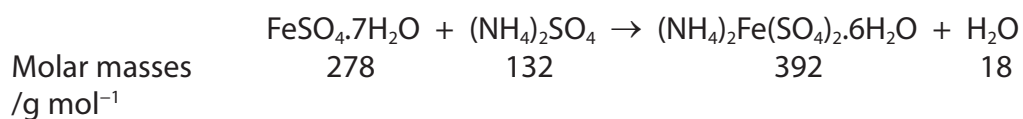
(a) What mass of Mohr's salt would be produced from 2.78 g of iron(II) sulfate with excess ammonium sulfate, if the yield in the reaction was 80%?

(1)

☒ **A** 2.22 g

☒ **B** 2.78 g

☒ **C** 3.14 g

☒ **D** 3.92 g

(b) How many **cations** are there in each mole of Mohr's salt?

[Avogadro constant, $L = 6.0 \times 10^{23}$ mol^{-1}]

(1)

☒ **A** 6.0 ^{23}

☒ **B** 1.2 ^{24}

☒ **C** 1.8 ^{24}

☒ **D** 3.0 ^{24}

(c) What is the percentage by mass of water in Mohr's salt?

(1)

☒ **A** 4.6%

☒ **B** 18%

☒ **C** 28%

☒ **D** 72%

(Total for Question 1 = 3 marks)

2 Magnesium carbonate reacts with hydrochloric acid.

$$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + CO_2(g) + H_2O(l)$$

(a) What mass of magnesium carbonate would react with excess hydrochloric acid to produce 240 cm³ of carbon dioxide, measured at room temperature and pressure?

Data: 1 mol of any gas occupies 24.0 dm³ at room temperature and pressure

Molar mass of magnesium carbonate = 84.3 g mol⁻¹

(1)

☒ **A** 0.843 g

☒ **B** 8.43 g

☒ **C** 84.3 g

☒ **D** 843 g

(b) What is the **minimum** mass of magnesium carbonate needed to neutralise 50.0 cm³ of 0.250 mol dm⁻³ hydrochloric acid?

(1)

☒ **A** 0.423 g

☒ **B** 0.527 g

☒ **C** 1.05 g

☒ **D** 2.11 g

(c) What would be seen at the end of the reaction with excess acid?

(1)

☒ **A** A colourless solution

☒ **B** A coloured solution

☒ **C** A white precipitate

☒ **D** A coloured precipitate

(Total for Question 2 = 3 marks)

3 The conduction of electricity by a solution is evidence that ions are present in the solution.

What could be formed when an electric current is passed through **aqueous** sodium chloride?

☒ **A** Chlorine at the anode

☒ **B** Hydrogen at the anode

☒ **C** Sodium at the cathode

☒ **D** Oxygen at the cathode

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4 2000 g of a solution contains 0.015 g of solute.

In the solution, the concentration of the solute in parts per million (ppm) is

☒ **A** 3.0

☒ **B** 7.5

☒ **C** 30

☒ **D** 75

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5 What is the concentration, in mol dm^{-3}, of a solution of 10.6 g of sodium carbonate, Na_2CO_3, in 250 cm^3 of solution?

☒ **A** 0.40

☒ **B** 0.25

☒ **C** 0.10

☒ **D** 0.025

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6 Solutions of barium chloride and silver nitrate are mixed together.
The reaction that takes place is an example of

☒ **A** displacement.

☒ **B** neutralization.

☒ **C** oxidation.

☒ **D** precipitation.

7 The Avogadro constant is numerically equal to the number of

☒ **A** ions in 1 mol of sodium chloride, NaCl

☒ **B** atoms in 1 mol of hydrogen gas, H_2

☒ **C** electrons in 1 mol of helium gas, He

☒ **D** molecules in 1 mol of oxygen gas, O_2

8 10 g of magnesium is added to 1 $mol\,dm^{-3}$ copper(II) sulfate solution and the mixture is stirred until no further reaction occurs.

Which of the following is a result of this reaction?

☒ **A** The resulting solution is colourless.

☒ **B** 10 g of copper is displaced.

☒ **C** 63.5 g of copper is displaced.

☒ **D** All the magnesium reacts.

9 Which of the following gas samples has the same volume as 7.0 g of carbon monoxide?

All volumes are measured at the same temperature and pressure.

  ☒ **A** 1.0 g of hydrogen

  ☒ **B** 3.5 g of nitrogen

  ☒ **C** 10.0 g of argon

  ☒ **D** 35.5 g of chlorine

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10 Which of the following aqueous solutions contains the greatest number of **negative** ions?

  ☒ **A** 500 cm^3 of 0.10 mol dm^{-3} Na$_2$SO$_4$(aq)

  ☒ **B** 250 cm^3 of 0.12 mol dm^{-3} BaCl$_2$(aq)

  ☒ **C** 250 cm^3 of 0.15 mol dm^{-3} KI(aq)

  ☒ **D** 500 cm^3 of 0.10 mol dm^{-3} Zn(NO$_3$)$_2$(aq)


11 In an experiment carried out at 200 °C and 1 atm pressure, 20 cm^3 of ammonia gas reacted with an excess of heated copper(II) oxide.

$$3CuO(s) + 2NH_3(g) \rightarrow 3Cu(s) + 3H_2O(g) + N_2(g)$$

If all measurements were made at 200 °C and 1 atm pressure, what would be the total volume, in cm^3, of gaseous products?

  ☒ **A** 10

  ☒ **B** 20

  ☒ **C** 30

  ☒ **D** 40

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12 Ammonia is manufactured from hydrogen and nitrogen in the Haber process.

$$3H_2(g) + N_2(g) \rightleftharpoons 2NH_3(g)$$
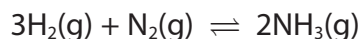
If 60 tonnes of hydrogen produces 80 tonnes of ammonia, what is the percentage yield in the reaction?

☒ **A** $\dfrac{80}{170} \times 100\%$

☒ **B** $\dfrac{80}{340} \times 100\%$

☒ **C** $\dfrac{30}{80} \times 100\%$

☒ **D** $\dfrac{60}{80} \times 100\%$

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13 A solution contains 33 ppm of solute. The mass of solute dissolved in 1 kg of this solution is

☒ **A** 33 g

☒ **B** 0.33 g

☒ **C** 0.033 g

☒ **D** 0.000033 g

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14 The Avogadro constant is equal to the number of

☒ **A** grams of an element which contains 6.02×10^{23} atoms of that element.

☒ **B** atoms contained in one mole of any element.

☒ **C** atoms contained in one mole of any monatomic element.

☒ **D** particles (atoms, ions or molecules) required to make one gram of a substance.

15 A hydrocarbon contains, by mass, 82.7% carbon and 17.3% hydrogen.

The **molecular** formula of the hydrocarbon is

☒ **A** CH_3

☒ **B** C_2H_6

☒ **C** C_2H_5

☒ **D** C_4H_{10}

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16 Calcium carbonate reacts with dilute nitric acid as follows:

$$CaCO_3(s) + 2HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + H_2O(l) + CO_2(g)$$
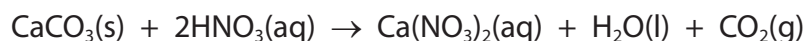
0.05 mol of calcium carbonate was added to a solution containing 0.08 mol of nitric acid.

Which of the following statements is true?

☒ **A** 0.05 mol of carbon dioxide is produced.

☒ **B** 0.08 mol of calcium nitrate is produced.

☒ **C** Calcium carbonate is in excess by 0.01 mol.

☒ **D** Nitric acid is in excess by 0.03 mol.

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17 In which of the following pairs does each gas occupy the same volume?

All volumes are measured at the same temperature and pressure.

☒ **A** 2 g of hydrogen and 14 g of nitrogen.

☒ **B** 32 g of methane and 88 g of carbon dioxide.

☒ **C** 7 g of carbon monoxide and 16 g of oxygen.

☒ **D** 10 g of hydrogen chloride and 10 g of sulfur dioxide.

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18 Consider the reaction below.

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$
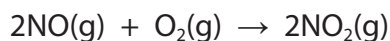
What is the maximum volume, in dm^3, of nitrogen dioxide that could be obtained in the reaction occurring when 1 dm^3 of nitrogen monoxide is mixed with 2 dm^3 of oxygen, under suitable conditions?

All measurements are made at the same temperature and pressure.

- ☒ **A** 1
- ☒ **B** 2
- ☒ **C** 3
- ☒ **D** 4

19 In an experiment, 3.425 g of lead oxide was reduced to form 3.105 g of lead.

The empirical formula of the lead oxide is

- ☒ **A** PbO
- ☒ **B** Pb_3O_2
- ☒ **C** Pb_3O_4
- ☒ **D** Pb_4O_3

20 Phenol, C_6H_5OH, is converted into trichlorophenol (known as TCP), $C_6H_2Cl_3OH$, according to the equation below.

$$C_6H_5OH + 3Cl_2 \rightarrow C_6H_2Cl_3OH + 3HCl$$
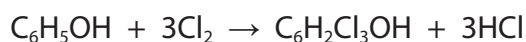
If 50.0 g of phenol produces 97.6 g of TCP, what is the percentage yield of the TCP?

[Molar masses: phenol = 94 g mol^{-1}; TCP = 197.5 g mol^{-1}]

- ☒ **A** 47.6%
- ☒ **B** 49.4%
- ☒ **C** 51.2%
- ☒ **D** 92.9%

21 If the price of one tonne (1000 kg) of sulfur, S, is £160, what is the cost (to the nearest pound) of the sulfur needed to make one tonne of sulfuric acid, H_2SO_4?

⊠ **A** £52

⊠ **B** £98

⊠ **C** £160

⊠ **D** £490

22 An oxide of nitrogen contains 2.8 g of nitrogen and 8.0 g of oxygen.
What is the empirical formula of this oxide?

⊠ **A** NO

⊠ **B** NO_3

⊠ **C** N_2O_3

⊠ **D** N_2O_5

23 Calculate the total number of **atoms** present in 1.8 g of water, H_2O.

DATA
- The molar mass of H_2O is 18 g mol^{-1}
- The Avogadro constant is 6.0×10^{23} mol^{-1}

⊠ **A** 6.0×10^{22}

⊠ **B** 6.0×10^{23}

⊠ **C** 1.8×10^{23}

⊠ **D** 1.8×10^{24}

24 Calculate the mass of hydrated sodium thiosulfate, $Na_2S_2O_3 \cdot 5H_2O$, required to prepare 200 cm^3 of a 0.100 mol dm^{-3} solution.

[Assume that the molar mass of $Na_2S_2O_3 \cdot 5H_2O$ is 248 g mol^{-1}]

 ☒ **A** 0.124 g

 ☒ **B** 4.96 g

 ☒ **C** 24.8 g

 ☒ **D** 4960 g

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25 A 27.0 g sample of an unknown hydrocarbon, C_xH_y, was burned completely in excess oxygen to form 88.0 g of carbon dioxide and 27.0 g of water.

[Molar masses / g mol^{-1}: $CO_2 = 44$; $H_2O = 18$]

Which of the following is a possible formula of the unknown hydrocarbon?

 ☒ **A** CH_4

 ☒ **B** C_2H_6

 ☒ **C** C_4H_6

 ☒ **D** C_6H_6

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26 The Avogadro constant is equal to the number of

 ☒ **A** grams of any element which contains 6.0×10^{23} atoms of that element.

 ☒ **B** atoms contained in one mole of any element in its standard state.

 ☒ **C** particles (atoms, ions or molecules) required to make one gram of a substance.

 ☒ **D** atoms contained in one mole of any monatomic element.

27 Nitrogen monoxide, NO, can be made by the catalytic oxidation of ammonia, NH_3.

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$

In an experiment, 8.5 g of ammonia reacted to form 15.0 g of nitrogen monoxide.
The percentage yield of nitrogen monoxide in this experiment is

☒ **A** 50%

☒ **B** 57%

☒ **C** 100%

☒ **D** 176%

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28 Calculate the mass, in grams, of silver chloride, AgCl, formed when excess silver nitrate solution is added to 55.0 cm^3 of a 0.200 mol dm^{-3} solution of potassium chloride.

[The molar mass of AgCl = 143.4 g mol^{-1}]

$$AgNO_3(aq) + KCl(aq) \rightarrow AgCl(s) + KNO_3(aq)$$
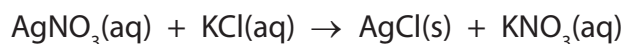
☒ **A** 1.10 g

☒ **B** 1.58 g

☒ **C** 7.89 g

☒ **D** 11.0 g

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29 Calculate the number of **atoms** in one mole of hydrogen peroxide, H_2O_2.

[The Avogadro constant, $L = 6.0 \times 10^{23}$ mol^{-1}]

☒ **A** 1.5×10^{23}

☒ **B** 6.0×10^{23}

☒ **C** 1.2×10^{24}

☒ **D** 2.4×10^{24}

30   When 0.1 mol of atoms of an element reacts with chlorine, there is an increase in mass of 7.1 g.

The element could be

☒ **A**   carbon.

☒ **B**   sodium.

☒ **C**   magnesium.

☒ **D**   aluminium.

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31 Magnesium nitrate is decomposed by heat in the following reaction.

$$2Mg(NO_3)_2(s) \rightarrow 2MgO(s) + 4NO_2(g) + O_2(g)$$

In an experiment, 0.10 mol of magnesium nitrate was heated. What is the maximum volume of gas, measured in dm^3 at room temperature and pressure, which could be obtained?

[Molar volume of a gas = 24 dm^3 mol^{-1} at room temperature and pressure]

☒ **A**   0.24

☒ **B**   2.4

☒ **C**   4.8

☒ **D**   6.0

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32 Ammonia gas decomposes when heated.

$$2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$$
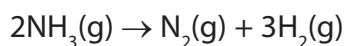
In an experiment, a sample of 500 cm^3 of ammonia was heated and 20% decomposed.

The total volume of gas present at the end of the experiment, in cm^3, was

☒ **A**   200

☒ **B**   400

☒ **C**   600

☒ **D**   1000

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33 (a) The relative atomic masses of elements can be determined using a mass spectrometer.

    (i) Define the term **relative atomic mass**.

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    (ii) Describe fully how positive ions are formed from gaseous atoms in a
         mass spectrometer.

                                                                 (2)

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(iii) The following data were obtained from the mass spectrum of a sample of strontium.

Mass / charge ratio	% abundance
84.0	0.56
86.0	9.86
87.0	7.02
88.0	82.56

Calculate the relative atomic mass of strontium in this sample.

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

(2)

(b) In which block of the Periodic Table is strontium found?

(1)

(c) Draw the dot and cross diagram for strontium chloride.

Show **outer** electrons only.

(2)

(d) A solution of strontium nitrate was prepared from strontium oxide and dilute nitric acid.

Write the equation for this reaction, including state symbols.

(2)

(e) A compound of strontium contains 49.9% strontium, 13.7% carbon and 36.4% oxygen, by mass.

Calculate the empirical formula for this compound.

[Use relative atomic masses: Sr = 87.6, C = 12.0, O = 16.0]

(3)

(Total for Question 33 = 15 marks)

34 The diagram below shows the pattern in the first ionization energies of the first 18 elements.

(a) Give the equation, including state symbols, for the first ionization energy of fluorine.

(2)

*(b) Explain why there is a **general** increase in the first ionization energies from sodium to argon.

(3)

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(c) *(i) Explain why the first ionization energy of aluminium ($Z = 13$) is less than that of magnesium ($Z = 12$).

(2)

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*(ii) Explain why the first ionization energy of sulfur ($Z = 16$) is less than that of phosphorus ($Z = 15$).

(2)

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(d) The table below, which is incomplete, refers to the elements sodium to sulfur.

Element	Na	Mg	Al	Si	P	S
Melting temperature	low	high				
Structure		giant				
Electrical conductivity		high		✕		

(i) Complete the **melting temperature** row by using only the words 'high' or 'low'.
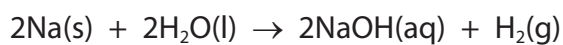
(2)

(ii) Complete the **structure** row by using only the words 'giant' or 'molecular'.

(2)

(iii) Complete the **electrical conductivity** row by using only the words 'high' or 'low'.

(1)

(e) In an experiment, 2.76 g of sodium completely reacted with water to form 500 cm³ of aqueous sodium hydroxide.

$$2Na(s) \ + \ 2H_2O(l) \ \rightarrow \ 2NaOH(aq) \ + \ H_2(g)$$

(i) Calculate the number of moles of sodium that reacted.

(1)

(ii) Calculate the maximum volume, in dm³, of hydrogen that can be formed at room temperature and pressure.

[1 mol of any gas occupies 24 dm³ at room temperature and pressure.]

(2)

(iii) Calculate the concentration, in mol dm⁻³, of the sodium hydroxide solution, NaOH(aq), formed in the experiment.

(2)

(Total for Question 34 = 19 marks)