2.6 Quantitative Chemistry: 1-hour Pack

AQA 8462 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A simple titration gives the following results for the volume of acid used to neutralise a fixed volume of alkali: 23.4 cm^3, 23.6 cm^3, 23.2 cm^3. Calculate the mean volume of acid used. Give the answer to 3 significant figures.

(Total for Question 1 is 3 marks)

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2 A student has 36 g of water. Calculate how many moles of water this is. Use Mr of water = 18 and the equation moles = mass / Mr.

(Total for Question 2 is 2 marks)

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3 Magnesium oxide has formula MgO. A student reacts 24 g of magnesium with excess oxygen to form magnesium oxide. Calculate the mass of magnesium oxide produced. (Ar: Mg = 24, O = 16)

Note: assume all magnesium reacts and conservation of mass applies.

(Total for Question 3 is 3 marks)

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4 Sulfuric acid, H_2SO_4, is used to make a 0.20 mol per dm3 solution. Calculate the number of moles of H_2SO_4 needed to make 250 cm^3 of this solution. (Remember 1000 cm^3 = 1 dm3.)

(Total for Question 4 is 3 marks)

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5 Calcium carbonate, $CaCO_3$, thermally decomposes when heated strongly. (Ar: Ca = 40, C = 12, O = 16)

(a) Calculate the relative formula mass (Mr) of calcium carbonate, $CaCO_3$. **(2)**

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(b) Write the balanced symbol equation for the thermal decomposition of calcium carbonate into calcium oxide and carbon dioxide. **(2)**

(c) Calculate the Mr of calcium oxide, CaO. **(1)**

.....

(Total for Question 5 is 5 marks)

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6 Sodium chloride, NaCl, has Mr = 58.5 (Na = 23, Cl = 35.5).

(a) Calculate the number of moles in 11.7 g of sodium chloride. **(2)**

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(b) Calculate the mass of 0.25 mol of sodium chloride. **(2)**

.....

(Total for Question 6 is 4 marks)

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7 A student, Priya, prepares copper sulfate crystals in the lab. Her calculated theoretical yield was 12.5 g but she only obtained 9.8 g of dry crystals.

(a) Calculate the percentage yield of Priya's preparation. **(2)**

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(b) Give two reasons why the percentage yield of a practical preparation is often less than 100%. **(2)**

.....

.....

(Total for Question 7 is 4 marks)

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8 Magnesium reacts with hydrochloric acid: $Mg + 2HCl \rightarrow MgCl_2 + H_2$ (Ar: Mg = 24, Cl = 35.5; Mr of $MgCl_2$ = 95)

(a) Calculate the number of moles of magnesium in 3.6 g of magnesium. **(2)**

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(b) Assuming the hydrochloric acid is in excess, calculate the maximum mass of magnesium chloride, $MgCl_2$, that could be produced from 3.6 g of magnesium. **(3)**

.....

(Total for Question 8 is 5 marks)

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9 A sample contains 0.25 mol of hydrogen gas. Calculate the number of molecules of hydrogen present. Use Avogadro constant = 6.0×10^{23} mol^{-1}. (Give your answer in standard form.)

(Total for Question 9 is 2 marks)

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10 A teacher asks pupils to find the mass of one mole of calcium carbonate, $CaCO_3$. Calculate its Mr and then the mass of 2.5 mol of $CaCO_3$. (Ar: Ca = 40, C = 12, O = 16.)

(Total for Question 10 is 4 marks)

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11 A gas cylinder contains 6.0 mol of oxygen gas, O_2, at room temperature and pressure.

Calculate the volume of gas in the cylinder, using the molar volume of a gas at rtp = 24 dm3/mol.

(Total for Question 11 is 2 marks)

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12 Calculate the relative formula mass, Mr, of ammonium sulfate, $(NH_4)_2SO_4$. Relative atomic masses: N = 14, H = 1, S = 32, O = 16.

(Total for Question 12 is 3 marks)

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13 Extended response (6 marks).

A student is asked to find the concentration of a hydrochloric acid solution using a titration with a standard solution of sodium carbonate, Na_2CO_3, of known concentration 0.100 mol/dm3.

Describe how the student should carry out this titration accurately, and explain how the results should be used to calculate the concentration of the hydrochloric acid.

(Total for Question 13 is 6 marks)

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Mark scheme · 2.6 Quantitative Chemistry: 1-hour Pack

Question 1

calculate mean: (23.4 + 23.6 + 23.2) / 3 = 70.2 / 3	**M1**
value = 23.4	**M1**
mean = 23.4 cm^3 to 3 s.f. cao	**A1**

Answer: 23.4 cm^3

Question 2

substitutes into moles = mass / Mr: moles = 36 / 18	**M1**
2.0 mol cao	**A1**

Answer: 2.0 mol

Question 3

calculate moles of Mg: moles = 24 / 24 = 1	**M1**
use reaction ratio Mg : MgO = 1 : 1 so moles MgO = 1	**M1**
mass MgO = moles x Mr = 1 x (24 + 16) = 40 g cao	**A1**

Answer: 40 g

Question 4

convert volume: 250 cm^3 = 0.250 dm3	**M1**
use moles = concentration x volume: moles = 0.20 x 0.250	**M1**
moles = 0.050 mol cao	**A1**

Answer: 0.050 mol

Question 5

(a) 40 + 12 + (3 x 16) shown	**M1**
(a) 100 (cao)	**A1**

(a) Answer: 100

(b) correct formulae: $CaCO_3$, CaO, CO_2	**B1**
(b) correctly balanced: $CaCO_3$ -> CaO + CO_2	**B1**

(b) Answer: $CaCO_3$ -> CaO + CO_2

(c) 56 (cao)	**A1**

(c) Answer: 56

Question 6

(a) moles = mass / Mr = 11.7 / 58.5 shown	**M1**
(a) 0.2 mol (cao)	**A1**

(a) Answer: 0.2 mol

(b) mass = moles x Mr = 0.25 x 58.5 shown	**M1**
(b) 14.625 g (accept 14.6 g)	**A1**

(b) Answer: 14.625 g (accept 14.6 g)

Question 7

(a) percentage yield = (actual yield / theoretical yield) x 100 = (9.8 / 12.5) x 100 shown	**M1**
(a) 78.4% (awrt)	**A1**

(a) Answer: 78.4%

(b) Product is lost during practical steps such as filtration, transferring between containers or evaporation (oe), e.g. crystals left on filter paper	**B1**
(b) The reaction may not go to completion, or unwanted side/reverse reactions occur, producing other products (oe)	**B1**

(b) Answer: Any two of: product lost during transfer/filtration; reaction does not go to completion; unwanted side reactions occur.

Question 8

(a) moles = mass / Ar = 3.6 / 24 shown	**M1**
(a) 0.15 mol (cao)	**A1**

(a) Answer: 0.15 mol

(b) uses 1:1 mole ratio Mg : $MgCl_2$ from the equation, so moles $MgCl_2$ = 0.15 mol (ft from a)	**M1**
(b) mass = moles x Mr = 0.15 x 95 shown	**M1**
(b) 14.25 g (cao)	**A1**

(b) Answer: 14.25 g

Question 9

substitutes: number = 0.25 x 6.0 x 10^{23}	**M1**
1.5 x 10^{23} molecules cao	**A1**

Answer: 1.5 x 10^{23} molecules

Question 10

calculate Mr: Mr = 40 + 12 + (3 x 16)	**M1**
Mr = 100	**M1**
mass = moles x Mr = 2.5 x 100	**M1**
mass = 250 g cao	**A1**

Answer: 250 g

Question 11

substitutes: volume = 6.0 x 24	**M1**
144 dm3 cao	**A1**

Answer: 144 dm3

Question 12

identifies atoms present: N x 2, H x 8, S x 1, O x 4	**M1**
substitutes: Mr = (2 x 14) + (8 x 1) + 32 + (4 x 16)	**M1**
132 cao	**A1**

Answer: 132

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Question 13

Level 3 A detailed, correctly sequenced method using appropriate apparatus (pipette, burette, indicator), a clear description of achieving concordant results, and a correct, logically explained calculation route from titre to concentration of HCl, including the mole ratio. **5-6**

Level 2 A mostly correct method with some detail missing (e.g. repeats or indicator not mentioned), and a broadly correct but incomplete explanation of the calculation route. **3-4**

Level 1 A brief or partial description of a titration with little or no explanation of how the concentration is calculated from the results. **1-2**

Indicative content:

- Use a pipette (with a pipette filler) to measure a known, fixed volume of the sodium carbonate solution (e.g. 25.0 cm^3) accurately into a conical flask, and add a few drops of a suitable indicator such as methyl orange.
- Fill a burette with the hydrochloric acid, record the initial reading, then add the acid to the flask while swirling, stopping when the indicator just changes colour at the end point; record the final reading.
- Repeat the titration until at least two concordant results (within 0.10 cm^3 of each other) are obtained, and calculate a mean titre using only the concordant results, ignoring any anomalous readings.
- Calculate the number of moles of sodium carbonate used, from moles = concentration x volume, using the known concentration and volume pipetted.
- Use the balanced equation's mole ratio between Na_2CO_3 and HCl ($2HCl + Na_2CO_3 \rightarrow 2NaCl + H_2O + CO_2$, ratio 1:2) to find the moles of HCl that reacted.
- Calculate the concentration of the HCl using concentration = moles / volume, using the mean titre volume (converted to dm3).

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