2.20 Moles, Formulae and Equations: 30-minute Pack

AQA 8464 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A student has 8.0 g of sodium hydroxide, NaOH (Mr = 40), and 25 g of calcium carbonate, $CaCO_3$ (Mr = 100).

(a) Calculate the number of moles of sodium hydroxide in the 8.0 g sample. **(2)**

.....

(b) Calculate the number of moles of calcium carbonate in the 25 g sample. **(1)**

.....

(c) State, using your answers to (a) and (b), which sample contains the greater number of moles. **(1)**

(Total for Question 1 is 4 marks)

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2 Key words and equations used throughout this worksheet. [Relative atomic masses, Ar: H = 1, C = 12, N = 14, O = 16, Na = 23, Mg = 24, Al = 27, S = 32, Cl = 35.5, Ca = 40, Fe = 56]

(a) State what is meant by the term 'relative formula mass' (Mr). **(1)**

(b) State what is meant by the term 'empirical formula'. **(1)**

(c) State the law of conservation of mass. **(1)**

(d) State what is meant by 'one mole' of a substance. **(1)**

(e) State the equation that links the number of moles (n), the mass in grams (m) and the relative formula mass (Mr) of a substance. **(1)**

(Total for Question 2 is 5 marks)

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3 Required practical: determining the empirical formula of magnesium oxide.

A student, Aaliyah, investigates the empirical formula of magnesium oxide. She:

1. Weighs an empty crucible and lid.
2. Adds a coiled piece of magnesium ribbon and weighs the crucible, lid and magnesium.
3. Heats the crucible strongly on a pipe-clay triangle and tripod, lifting the lid slightly at intervals, until the magnesium has completely reacted and the mass is constant.
4. Allows the crucible to cool, then weighs the crucible, lid and solid product.

Her results:

Mass of empty crucible and lid = 24.62 g

Mass of crucible, lid and magnesium = 24.86 g

Mass of crucible, lid and solid product (after heating) = 25.02 g

(a) Calculate the mass of magnesium used in the experiment. **(1)**

.....

(b) Calculate the mass of oxygen that combined with the magnesium. **(1)**

.....

(c) Use your answers to (a) and (b) to determine the empirical formula of magnesium oxide. Show your working. **(3)**

(d) Give one reason why the lid was lifted slightly at intervals during heating. **(1)**

.....

(e) Explain why the lid was lifted only slightly, rather than removed completely. **(1)**

.....

(f) Evaluate this method for determining the empirical formula of magnesium oxide. In your answer, refer to possible sources of error, their effect on the calculated formula, and how the method could be improved. **(6)**

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(Total for Question 3 is 13 marks)

4 Determine the empirical formula of this compound. Show your working.

(Total for Question 4 is 3 marks)

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Mark scheme · 2.20 Moles, Formulae and Equations: 30-minute Pack

Question 1

(a) substitutes: moles = 8.0 / 40 **M1**

(a) 0.2 mol cao **A1**

(a) Answer: 0.2 mol

(b) 0.25 mol (25 / 100) cao **B1**

(b) Answer: 0.25 mol

(c) the calcium carbonate sample (0.25 mol is greater than 0.2 mol), ecf from (a) and (b) **B1**

(c) Answer: The calcium carbonate sample, since 0.25 mol is greater than 0.2 mol.

Question 2

(a) the sum of the relative atomic masses of all the atoms shown in the formula of a substance (oe) **B1**

(a) Answer: The relative formula mass (Mr) is the sum of the relative atomic masses of all the atoms shown in the formula of a substance.

(b) the simplest whole-number ratio of the atoms of each element present in a compound (oe) **B1**

(b) Answer: The empirical formula is the simplest whole-number ratio of the atoms of each element in a compound.

(c) no atoms are created or destroyed in a chemical reaction, so the total mass of the reactants equals the total mass of the products (oe) **B1**

(c) Answer: No atoms are created or destroyed in a chemical reaction, so the total mass of the reactants equals the total mass of the products.

(d) the amount of a substance that contains $6.02 * 10^{23}$ particles (atoms, molecules or ions) of that substance (oe); accept reference to the Avogadro constant **B1**

(d) Answer: One mole of a substance contains $6.02 * 10^{23}$ particles (the Avogadro constant) of that substance.

(e) moles = mass / Mr (n = m / Mr), oe **B1**

(e) Answer: moles = mass (g) / Mr

Question 3

(a) 0.24 g cao (24.86 - 24.62) **B1**

(a) Answer: 0.24 g

(b) 0.16 g cao ((25.02 - 24.62) - mass of Mg from (a)); ft from candidate's (a) **B1**

(b) Answer: 0.16 g

(c) moles Mg = 0.24 / 24 = 0.01 mol; ft from (a) **M1**

(c) moles O = 0.16 / 16 = 0.01 mol; ft from (b) **M1**

(c) MgO cao, from a correctly identified 1:1 ratio **A1**

(c) Answer: MgO

(d) to let air/oxygen into the crucible so that all of the magnesium can react (oe) **B1**

(d) Answer: Lifting the lid lets air (oxygen) into the crucible so that all of the magnesium can react completely.

(e) to minimise the amount of white magnesium oxide smoke/powder that escapes; if too much escaped, the measured mass (and calculated formula) would be inaccurate/too low (oe) **B1**

(e) Answer: Removing the lid completely would let more of the white magnesium oxide smoke escape, lowering the measured mass and making the calculated formula less accurate.

(f) **L3** A detailed and coherent evaluation is given, covering more than one source of error, each clearly linked to its effect on the calculated formula, together with at least one justified, practical improvement. The answer is well structured, using appropriate scientific terminology throughout. **5-6**

(f) **L2** Some relevant sources of error and/or improvements are described, with a partial explanation of how they would affect the calculated formula. The answer has some structure. **3-4**

(f) **L1** Simple, isolated statement(s) about a source of error or an improvement, with little or no explanation of the effect on the result. The answer may lack a logical structure. **1-2**

(f) **L0** No relevant content. **0**

(f) Indicative content:

- Magnesium oxide smoke/powder can escape from the crucible while the lid is lifted, or if it is not well fitted, so the final mass measured is lower than it should be.
- A lower final mass means the calculated mass of oxygen combined is too low, which could give an inaccurate mole ratio and formula.
- Magnesium can react with nitrogen in the air, as well as oxygen, forming magnesium nitride; this adds extra mass that is not accounted for by the mass of oxygen alone.
- If heating stops before all the magnesium has reacted, the final mass will be lower than expected and the calculated ratio of magnesium to oxygen will be inaccurate.
- The crucible should be heated, cooled, weighed, then reheated and reweighed repeatedly until the mass is constant, to check that the reaction is complete.
- Weighing the crucible while it is still hot can give an inaccurate reading, due to convection currents/expansion affecting the balance; it should be allowed to cool fully before each weighing.
- Improvement: use a lid with a small hole, which lets oxygen in but reduces the loss of solid smoke/product.
- Improvement: repeat the experiment and calculate a mean value for the mass of oxygen combined, to reduce the effect of random errors.

(f) Answer: See levels/indicative content.

Question 4

moles C = 1.2/12 = 0.1 mol and moles O = 3.2/16 = 0.2 mol **M1**

correct simplest whole-number ratio shown, e.g. 0.1 : 0.2 = 1 : 2 **M1**

CO_2 cao **A1**

Answer: CO_2

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