2.20 Moles, Formulae and Equations: 1-hour Pack

AQA 8464 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Determine the molecular formula of X.

(Total for Question 1 is 3 marks)

2 Calculate the maximum mass of calcium oxide that could be produced from 500 kg of calcium carbonate.

(Total for Question 2 is 3 marks)

3 Calculate the mass of aluminium oxide formed when 5.4 g of aluminium reacts completely with oxygen.

(Total for Question 3 is 3 marks)

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4 Calculate the mass of calcium hydroxide produced when 5.6 g of calcium oxide reacts completely with water.

(Total for Question 4 is 3 marks)

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5 This question is about the Avogadro constant, which is $6.02 * 10^{23}$ per mole.

(a) State the value of the Avogadro constant, including its units. **(1)**

(b) Calculate the number of atoms in 0.50 mol of iron. **(2)**

(Total for Question 5 is 3 marks)

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6 For each question, identify the correct answer from the options given.

(a) Which equation below is correctly balanced? **(1)**

- ☐ A) $Mg(s) + O_2(g) \rightarrow MgO(s)$
- ☐ B) $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$
- ☐ C) $2Mg(s) + 2O_2(g) \rightarrow 2MgO(s)$
- ☐ D) $Mg(s) + 2O_2(g) \rightarrow 2MgO(s)$

(b) Which statement correctly describes the law of conservation of mass? **(1)**

- ☐ A) The total mass of the products is always greater than the total mass of the reactants, because energy is added during a reaction.
- ☐ B) Atoms can be created during a chemical reaction, but they can never be destroyed.
- ☐ 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 in a closed system.
- ☐ D) Mass is only conserved in reactions that produce a precipitate.

(c) Glucose has the molecular formula $C_6H_{12}O_6$. Which of the following is its empirical formula? **(1)**

- ☐ A) $C_6H_{12}O_6$
- ☐ B) $C_3H_6O_3$
- ☐ C) CH_2O
- ☐ D) $C_2H_4O_2$

(Total for Question 6 is 3 marks)

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7 Balance each equation by writing the correct number in front of each formula (leave a blank if the number is 1).

(a) __Mg(s) + __O2(g) -> __MgO(s) **(1)**

(b) __Na(s) + __Cl2(g) -> __NaCl(s) **(1)**

(c) __Fe(s) + __Cl2(g) -> __FeCl3(s) **(1)**

(Total for Question 7 is 3 marks)

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8 These equations are harder to balance. Write the correct number in front of each formula (leave a blank if the number is 1).

(a) Complete combustion of propane: __C3H8(g) + __O2(g) -> __CO2(g) + __H2O(g) **(2)**

(b) Thermite reaction: __Al(s) + __Fe2O3(s) -> __Al2O3(s) + __Fe(s) **(2)**

(c) Complete combustion of ethane: __C2H6(g) + __O2(g) -> __CO2(g) + __H2O(g) **(2)**

(Total for Question 8 is 6 marks)

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9 Calculate the relative formula mass (Mr) of ammonium sulfate, $(NH_4)_2SO_4$. Show your working.

(Total for Question 9 is 2 marks)

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10 A compound contains only carbon, hydrogen and oxygen. A sample of the compound contains 1.2 g of carbon, 0.2 g of hydrogen and 1.6 g of oxygen. Relative atomic masses: C = 12, H = 1, O = 16.

(a) Calculate the number of moles of carbon atoms, hydrogen atoms and oxygen atoms in the sample. **(3)**

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(b) Use your answers to (a) to determine the empirical formula of the compound. **(2)**

(Total for Question 10 is 5 marks)

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11 A student carries out the required practical to determine the empirical formula of magnesium oxide, but their calculated ratio of magnesium to oxygen comes out as approximately 1 : 0.5, instead of the expected 1 : 1 (MgO). Evaluate possible practical errors that could explain this result, and suggest how the practical could be improved to give a more accurate ratio.

(Total for Question 11 is 6 marks)

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12 Determine which reactant is in excess, and calculate the maximum mass of ammonia that could be formed. Show all of your working.

(Total for Question 12 is 5 marks)

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Mark scheme · 2.20 Moles, Formulae and Equations: 1-hour Pack

Question 1

empirical formula mass of CH_2 = 12 + 2*1 = 14 **M1**

84 / 14 = 6 **M1**

C_6H_{12} cao **A1**

Answer: C_6H_{12}

Question 2

Mr($CaCO_3$) = 100 and Mr(CaO) = 56 identified/used **M1**

correct use of the 1:1 mole ratio scaled to 500 kg, e.g. 500 * (56/100) **M1**

280 kg cao (accept awrt 280 kg) **A1**

Answer: 280 kg

Question 3

moles Al = 5.4/27 = 0.2 mol **M1**

correct use of the 4:2 (2:1) mole ratio between Al and Al_2O_3, e.g. moles Al_2O_3 = 0.2 * (2/4) = 0.1 mol **M1**

10.2 g cao (accept awrt 10.2 g) **A1**

Answer: 10.2 g

Question 4

moles CaO = 5.6/56 = 0.1 mol **M1**

correct use of the 1:1 mole ratio between CaO and $Ca(OH)_2$ **M1**

7.4 g cao (accept awrt 7.4 g); Mr($Ca(OH)_2$) = 74 **A1**

Answer: 7.4 g

Question 5

(a) $6.02 * 10^{23}$ per mole (mol^{-1}) cao **B1**

(a) Answer: $6.02 * 10^{23}$ per mole (mol^{-1})

(b) correct method: number of atoms = moles * Avogadro constant, e.g. $0.50 * 6.02*10^{23}$ **M1**

(b) $3.01 * 10^{23}$ (atoms) cao (accept awrt $3.01*10^{23}$) **A1**

(b) Answer: $3.01 * 10^{23}$ atoms

Question 6

(a) B **B1**

(a) Answer: B

(b) C **B1**

(b) Answer: C

(c) C **B1**

(c) Answer: C

Question 7

(a) $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$, fully correctly balanced **B1**

(a) Answer: $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

(b) $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$, fully correctly balanced **B1**

(b) Answer: $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$

(c) $2Fe(s) + 3Cl_2(g) \rightarrow 2FeCl_3(s)$, fully correctly balanced **B1**

(c) Answer: $2Fe(s) + 3Cl_2(g) \rightarrow 2FeCl_3(s)$

Question 8

(a) at least two of the four coefficients correctly balanced relative to each other, e.g. 3 before CO_2 and 4 before H_2O **M1**

(a) $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$, fully correctly balanced **A1**

(a) Answer: $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$

(b) correct ratio identified for at least one pair, e.g. 2 Al to 1 Al_2O_3, or 1 Fe_2O_3 to 2 Fe **M1**

(b) $2Al(s) + Fe_2O_3(s) \rightarrow Al_2O_3(s) + 2Fe(s)$, fully correctly balanced **A1**

(b) Answer: $2Al(s) + Fe_2O_3(s) \rightarrow Al_2O_3(s) + 2Fe(s)$

(c) correct ratio of C_2H_6 to CO_2 (1:2) or to H_2O (1:3) shown, even if the whole equation is not yet balanced with whole numbers **M1**

(c) $2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(g)$, fully correctly balanced using whole-number coefficients **A1**

(c) Answer: $2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(g)$

Question 9

correct working shown, e.g. 2*(14 + 4*1) + 32 + 4*16 **M1**

132 cao **A1**

Answer: Mr($(NH_4)_2SO_4$) = 132

Question 10

(a) moles C = 1.2 / 12 = 0.1 **M1**

(a) moles H = 0.2 / 1 = 0.2 **M1**

(a) moles O = 1.6 / 16 = 0.1 **A1**

(a) Answer: C: 0.1 mol, H: 0.2 mol, O: 0.1 mol

(b) divides each mole value by the smallest value (0.1) to give the ratio C : H : O = 1 : 2 : 1, ecf from (a) **M1**

(b) CH_2O cao **A1**

(b) Answer: CH_2O

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Question 11

Level 3 A well-reasoned evaluation that identifies at least two plausible causes of the low oxygen ratio, explains how each would produce this specific result, and suggests linked, practical improvements.	**5-6**
Level 2 At least one plausible cause identified and explained, with at least one relevant improvement suggested, but the evaluation is not fully developed or linked.	**3-4**
Level 1 Simple, undeveloped statements about sources of error, with little or no explanation of how they affect the ratio, or unlinked improvements.	**1-2**

Indicative content:

- If the magnesium was not heated for long enough, or the lid was kept closed throughout, too little oxygen could reach the magnesium for it to react (oxidise) completely, so less oxygen combines than expected, giving a mass of oxygen (and ratio) that is too low
- If the crucible lid was lifted too much or too often, some white magnesium oxide smoke/particles could escape and be lost, reducing the final measured mass and so the calculated mass of oxygen gained
- The magnesium ribbon may not have been fully cleaned (e.g. an oxide layer already present on the surface before starting) which would not by itself explain a low ratio, but shows the need to control starting conditions
- Improvement: heat, cool and reweigh the crucible repeatedly until the mass is constant, to ensure the reaction has gone to completion
- Improvement: use a lid with a small gap (or lift briefly and replace quickly) so that some air can enter to supply oxygen while minimising the loss of solid product
- Improvement: repeat the whole experiment several times and calculate a mean ratio, to reduce the effect of random errors on the final result

Question 12

moles N_2 = 2.8/28 = 0.1 mol	**M1**
moles H_2 = 1.2/2 = 0.6 mol	**M1**
correct comparison shown: moles H_2 needed to react with 0.1 mol N_2 = 0.1*3 = 0.3 mol; since 0.6 mol H_2 is available (more than the 0.3 mol needed), H_2 is in excess and N_2 is the limiting reactant	**M1**
correct use of the limiting reactant (N_2) with the 1:2 mole ratio to NH_3: moles NH_3 = 0.1*2 = 0.2 mol; allow ecf if the candidate identifies the wrong limiting reactant but applies the mole-ratio method correctly and consistently from that point	**M1**
3.4 g cao (accept awrt 3.4 g); Mr(NH_3) = 17	**A1**

Answer: Nitrogen (N_2) is the limiting reactant; hydrogen is in excess; maximum mass of ammonia formed = 3.4 g

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