Quiz (Basic Chemical Calculation 1)

Section A: Multiple-choice

1. The haemoglobin in mammals contains 0.33% by mass of iron. Given that the molar mass of a haemoglobin molecule is 68 000, how many iron atoms are there in a haemoglobin molecule?
(Relative atomic mass: Fe = 55.8)
A. 2
B. 3
C. 4
D. 5

2. Which of the following gases has the least number of atoms?
(Relative atomic masses: C = 12.0, O = 16.0, Ne = 20.2, S = 32.1, Cl = 35.5)
A. 2.0 g of chlorine
B. 4.0 g of carbon dioxide
C. 6.0 g of sulphur dioxide
D. 8.0 g of neon

3. Iron(III) oxide is reduced by carbon to give iron. Let *w* be the relative atomic mass of iron. In an experiment *x* g of iron(III) oxide is reduced to *y* g of iron. Which of the following is the correct expression of *w*?
(Relative atomic mass: O = 16.0)
A. $\frac{24.0 \times y}{x - y}$
B. $\frac{x - y}{16.0 \times y}$
C. $\frac{x - y}{24.0 \times y}$
D. $\frac{16.0 \times (x - y)}{y}$

4. A mixture of sodium sulphate and copper(II) sulphate contains three moles of sulphate ions and one mole of copper(II) ions. How many moles of sodium ions are there in the mixture?
A. 1
B. 2
C. 3
D. 4

5. The relative atomic mass of metal *X* is 27.0. One mole of metal *X* burns completely in pure oxygen to form 51.0 g of the oxide. The empirical formula of the oxide is
(Relative atomic mass: O = 16.0)
A. X_2O.
B. X_2O_2.
C. X_2O_3.
D. X_3O_2.

6. Which of the following nitrides has the greatest percentage by mass of nitrogen?
(Relative atomic masses: Li = 6.9, N = 14.0, Na = 23.0, Mg = 24.3, Al = 27.0)
A. Li_3N
B. Na_3N
C. Mg_3N_2
D. AlN

7. 5.60 g of hydrocarbon *Y* is burnt completely to give 17.0 g of carbon dioxide. What is the empirical formula of *Y*?
(Relative atomic masses: H = 1.0, C = 12.0, O =16.0)
A. CH_3
B. C_2H_5
C. C_2H_6
D. C_4H_{10}

8. A metal carbonate XCO_3 contains 52.2% by mass of the metal. The metal is probably
(Relative atomic masses: C = 12.0, O = 16.0)
A. potassium.
B. calcium.
C. nickel.
D. zinc.

9. Which of the following statements about 1 dm^3 of neon and 1 dm^3 of fluorine is/are correct?
(1) They contain the same number of atoms.
(2) They contain the same number of molecules.
(3) They have the same mass.
A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

10. What is the volume of 11 g carbon dioxide at room temperature and pressure?
(Relative atomic masses: C = 12.0, O = 16.0; molar volume of gas at room temperature and pressure = 24.0 $dm^3\ mol^{-1}$)
A. 0.5 dm^3
B. 3.0 dm^3
C. 6.0 dm^3
D. 24.0 dm^3

11. The complete combustion of hydrocarbons gives carbon dioxide and water. What is the volume of gas formed (measured at room temperature and pressure) when 11.4 g of octane (C_8H_{18}) is burned completely at room temperature and pressure?
(Relative atomic masses: H = 1.0, C = 12.0; molar volume of gas at room temperature and pressure = 24.0 $dm^3\ mol^{-1}$)
A. 9.6 dm^3
B. 19.2 dm^3
C. 21.6 dm^3
D. 40.8 dm^3

12. Consider the following gases:
(1) 3 g of hydrogen (2) 8 g of helium (3) 12 g of oxygen
Which of the following is the descending order of the volume occupied by the gases at room temperature and pressure?
(Relative atomic masses: H = 1.0, He = 4.0, O = 16.0)
A. (2) > (1) > (3)
B. (1) > (2) > (3)
C. (1) > (3) > (2)
D. (3) > (1) > (2)

13. Which of the following gaseous mixture contains the largest number of atoms?
(Assume that there is no reaction between the two gases; relative atomic masses: H = 1.0, He = 4.0, C = 12.0, N = 14.0, O = 16.0, S = 32.1, Cl = 35.5)
A. 500 cm^3 of ammonia and 250 cm^3 of helium
B. 1 dm^3 of hydrogen and 1 dm^3 of hydrogen chloride
C. 5 g of sulphur dioxide and 5 g of nitrogen dioxide
D. 2 g of carbon dioxide and 2 g of nitrogen

Questions 14 and 15 refer to the production of acetylene through the reaction between calcium carbide (CaC_2) and water.

14. Which of the following equations represents the reaction between calcium carbide and water?
    A. $CaC_2(s) + H_2O(l) \longrightarrow C_2H_2(g) + CaO_2(s)$
    B. $CaC_2(s) + 2H_2O(l) \longrightarrow C_2H_4(g) + Ca(OH)_2(aq)$
    C. $CaC_2(s) + 2H_2O(l) \longrightarrow C_2H_4(g) + CaO(s)$
    D. $CaC_2(s) + 2H_2O(l) \longrightarrow C_2H_2(g) + Ca(OH)_2(aq)$

15. What is the volume of acetylene formed (measured at room temperature and pressure) when 6.4 g of calcium carbide is added to 25.0 cm^3 of water?
    (Relative atomic masses: C = 12.0, Ca = 40.1; density of water = 1.0 g cm^{-3}; molar volume of gas at room temperature and pressure = 24.0 dm^3 mol^{-1})
    A. 0.12 cm^3
    B. 0.24 cm^3
    C. 120 cm^3
    D. 240 cm^3

Section B: Structured questions

1. Xenon trioxide (XeO_3) is an unstable compound. It reacts with barium hydroxide ($Ba(OH)_2$) in alkaline medium to form a white substance. The white substance has the following percentage composition by mass:
   Ba: 64.4% Xe: 20.5% O: 15.1%
   (a) Deduce the empirical formula of the white substance.
   (Relative atomic masses: O = 16.0, Xe = 131.3, Ba = 137.3)

   (b) Write a chemical equation for the formation of the white substance.

2. 31.2 g of hydrated aluminium oxide ($Al_2O_3 \bullet xH_2O$) is heated to a constant mass of 20.2 g. Calculate the value of x.
   (Relative atomic masses: H = 1.0, O = 16.0, Al = 27.0)

3. One mole of ethane (C_2H_6) burns in the air under room temperature and pressure. Carbon dioxide and water vapour are formed.
   (a) Write a balanced chemical equation for the above reaction.

   (b) Calculate the volume of oxygen gas required for this reaction.

   (c) Calculate the volume of carbon dioxide gas formed for this reaction.

   (Molar volume of gas at room temperature and pressure = 24.0 dm^3 mol^{-1})

Suggested Answer

Section A

1.	C	6.	A	11.	B
2.	A	7.	B	12.	A
3.	A	8.	D	13.	C
4.	D	9.	B	14.	D
5.	C	10.	C	15.	D

Section B

1. (a) Assume there is 100 g of the white substance.

	Ba	**Xe**	**O**
Mass (g)	64.4	20.5	15.1
Number of moles of atoms (mol)	64.4 / 137.3 = 0.469	20.5 / 131.3 = 0.156	15.1 / 16.0 = 0.944
Mole ratio of atoms	0.469 / 0.156 = 3	0.156 / 0.156 = 1	0.9444 / 0.156 = 6

∴ the empirical formula of the white substance is Ba_3XeO_6.

(b) $3Ba(OH)_3 + XeO_3 \longrightarrow Ba_3XeO_6 + 3H_2O$

2.

	Al_2O_3	**H_2O**
Mass (g)	20.2	31.2 – 20.2 = 11.0
Number of moles of atoms (mol)	20.2 / (27.0 x 2 + 16.0 x 3) = 0.198	11.0 / (1.0 x 2 + 16.0) = 0.611
Mole ratio of atoms	0.198 / 0.198 = 1	0.611 / 0.198 = 3

∴ x = 3

3. (a) $2C_2H_6(g) + 7O_2(g) \longrightarrow 4CO_2(g) + 6H_2O(l)$

(b) Number of moles of $O_2(g)$ required
= 1 / 2 x 7
= 3.5

Volume of $O_2(g)$ required
= 3.5 x 24.0
= 84.0 dm^3

(c) Number of moles of $CO_2(g)$ formed
= 1 / 2 x 4
= 2

Volume of $CO_2(g)$ required
= 2 x 24.0
= 48.0 dm^3