

# Topic 1 Quantitative Chemistry

## ≡ Essentials ≡

1.) 12-g Carbon-12 = 1 mol =  $6.02 \times 10^{23}$

The "relative molecular mass" ( $M_r$ )  
is based on this definition  
and has no units.

↑  
i.e., molar  
mass w/o units!

2.)  $1 \text{ dm}^3 = 1000 \text{ cm}^3 = 1000 \text{ mL} = 1 \text{ L}$

Concentration = Molarity =  $\frac{\text{mol}}{\text{L}} = \text{mol} \cdot \text{dm}^{-3}$

Density =  $\frac{\text{g}}{\text{cm}^3} = \text{g} \cdot \text{cm}^{-3}$

### 3.) Gases

$$PV = nRT \text{ Kelvins}$$

$\uparrow$  kPa     $\uparrow$  dm<sup>3</sup>     $\uparrow$  mol     $\uparrow$  8.31

$$K = ^\circ C + 273$$

@ STP (273K, 101.3 kPa)

$$1 \text{ mol gas} = 22.4 \text{ dm}^3$$

Note:  $M_r = \frac{\text{mass}}{\text{mol}} = \frac{m}{n}$

$$n = \frac{m}{M_r}$$

$$\therefore PV = \left(\frac{m}{M_r}\right)RT$$

or

$$M_r = \frac{mRT}{PV}$$

## IB QUESTIONS – QUANTITATIVE CHEMISTRY

1. What is the mass in grams of one molecule of ethanoic acid  $\text{CH}_3\text{COOH}$ ?  
A. 0.1 B.  $3.6 \times 10^{25}$  C.  $1 \times 10^{-22}$  D. 60
2. Which is not a true statement?  
A. One mole of methane contains four moles of hydrogen atoms  
B. One mole of  $^{12}\text{C}$  has a mass of 12.00 g  
C. One mole of hydrogen gas contains  $6.02 \times 10^{23}$  atoms of hydrogen  
D. One mole of methane contains 75% of carbon by mass
3. A pure compound contains 24 g of carbon, 4 g of hydrogen and 32 g of oxygen.  
No other elements are present. What is the empirical formula of the compound?  
A.  $\text{C}_2\text{H}_4\text{O}_2$  B.  $\text{CH}_2\text{O}$  C.  $\text{CH}_4\text{O}$  D.  $\text{CHO}$
4. Which one of the following statements about  $\text{SO}_2$  is/are correct?  
I. One mole of  $\text{SO}_2$  contains  $1.8 \times 10^{24}$  atoms  
II. One mole of  $\text{SO}_2$  has a mass of 64 g  
A. Both I and II B. Neither I nor II C. I only D. II only
5. What is the empirical formula for the compound  $\text{C}_6\text{H}_5(\text{OH})_2$ ?  
A.  $\text{C}_6\text{H}_6\text{O}$  B.  $\text{C}_6\text{H}_5\text{O}_2\text{H}_2$  C.  $\text{C}_6\text{H}_7\text{O}$  D.  $\text{C}_6\text{H}_7\text{O}_2$
6. Phosphorus burns in oxygen to produce phosphorus pentoxide  $\text{P}_4\text{O}_{10}$ .  
What is the sum of the coefficients in the balanced equation?  
 $\_ \text{P}_4(\text{s}) + \_ \text{O}_2(\text{g}) \rightarrow \_ \text{P}_4\text{O}_{10}(\text{s})$   
A. 3 B. 5 C. 6 D. 7
7. Magnesium reacts with hydrochloric acid according to the following equation:  
 $\text{Mg}(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{MgCl}_2(\text{aq}) + \text{H}_2(\text{g})$   
What mass of hydrogen will be obtained if  $100 \text{ cm}^3$  of  $2.00 \text{ mol dm}^{-3}$   $\text{HCl}$  are added to 4.86 g of magnesium?  
A. 0.2g B. 0.4g C. 0.8g D. 2.0g
8. Butane burns in oxygen according to the equation below.  
 $2\text{C}_4\text{H}_{10}(\text{g}) + 13\text{O}_2(\text{g}) \rightarrow 8\text{CO}_2(\text{g}) + 10\text{H}_2\text{O}(\text{l})$   
If 11.6 g of butane is burned in 11.6 g of oxygen which is the limiting reagent?  
A. Butane C. Neither  
B. Oxygen D. Oxygen and butane
9. When  $250 \text{ cm}^3$  of  $3.00 \text{ mol dm}^{-3}$   $\text{HCl}(\text{aq})$  is added to  $350 \text{ cm}^3$  of  $2.00 \text{ mol dm}^{-3}$   $\text{HCl}(\text{aq})$  the concentration of the solution of hydrochloric acid obtained in  $\text{mol dm}^{-3}$  is:  
A. 2.42 B. 1.45 C. 2.90 D. 2.50
10. Sulfuric acid and sodium hydroxide react together according to the equation:  
 $\text{H}_2\text{SO}_4(\text{aq}) + 2\text{NaOH}(\text{aq}) \rightarrow \text{Na}_2\text{SO}_4(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$   
What volume of  $0.250 \text{ mol dm}^{-3}$   $\text{NaOH}$  is required to neutralise exactly  $25.0 \text{ cm}^3$  of  $0.125 \text{ mol dm}^{-3}$   $\text{H}_2\text{SO}_4$ ?  
A.  $25.0 \text{ cm}^3$  B.  $12.5 \text{ cm}^3$  C.  $50 \text{ cm}^3$  D.  $6.25 \text{ cm}^3$
11. Separate samples of two gases, each containing a pure substance, are found to have the same density under the same conditions of temperature and pressure. Which statement about these two samples **must** be correct?  
A. They have the same volume  
B. They have the same relative molecular mass  
C. There are equal numbers of moles of gas in the two samples  
D. They condense at the same temperature
12. Which expression represents the density of a gas sample of relative molar mass,  $M_r$ , at temperature  $T$ , and pressure,  $P$ ?  
A.  $\frac{PM_r}{T}$  B.  $\frac{RT}{PM_r}$  C.  $\frac{PM_r}{RT}$  D.  $\frac{RM_r}{PT}$
13. A  $250 \text{ cm}^3$  sample of an unknown gas has a mass of 1.42 g at  $35^\circ\text{C}$  and 0.85 atmospheres. Which expression gives its molar mass,  $M_r$ ? ( $R = 82.05 \text{ cm}^3 \text{ atm K}^{-1} \text{ mol}^{-1}$ )  
A.  $\frac{1.42 \times 82.05 \times 35}{0.25 \times 0.85}$  B.  $\frac{1.42 \times 82.05 \times 308}{0.25 \times 0.85}$  C.  $\frac{1.42 \times 250 \times 0.85}{82.05 \times 308}$  D.  $\frac{1.42 \times 82.05 \times 308}{250 \times 0.85}$
14. Aspirin,  $\text{C}_9\text{H}_8\text{O}_4$ , is made by reacting ethanoic anhydride,  $\text{C}_4\text{H}_6\text{O}_3$  ( $M_r = 102.1$ ), with 2-hydroxybenzoic acid ( $M_r = 138.1$ ), according to the equation:  
 $2\text{C}_7\text{H}_6\text{O}_3 + \text{C}_4\text{H}_6\text{O}_3 \rightarrow 2\text{C}_9\text{H}_8\text{O}_4 + \text{H}_2\text{O}$   
(a) If 15.0 g 2-hydroxybenzoic acid is reacted with 15.0 g ethanoic acid, determine the limiting reagent in this reaction.  
(b) Calculate the maximum mass of aspirin that could be obtained in this reaction.  
(c) If the mass obtained in this experiment was 13.7 g, calculate the percentage yield of aspirin.
15.  $14.48 \text{ g}$  of a metal sulfate with the formula  $\text{M}_2\text{SO}_4$  were dissolved in water. Excess barium nitrate solution was added in order to precipitate all the sulfate ions in the form of barium sulfate.  $9.336 \text{ g}$  of precipitate was obtained.  
(a) Calculate the amount of barium sulfate  $\text{BaSO}_4$  precipitated.  
(b) Calculate the amount of sulfate ions present in the  $14.48 \text{ g}$  of  $\text{M}_2\text{SO}_4$ .  
(c) What is the relative molar mass of  $\text{M}_2\text{SO}_4$ ?  
(d) Calculate the relative atomic mass of  $\text{M}$  and hence identify the metal.