CHEM 101+103 FIRST SEMISTER 1431-1432H
FIRST EXAM SOLUTIONS

1. What is the mass (in grams) of 1.1×10^{22} atom of gold (Au)?

A) 2.2 B) 2.8 C) 3.6 D) 3.9

SOLUTION

$$m = n \times M = \frac{N}{N_A} \times M = \frac{1.1 \times 10^{22}}{6.022 \times 10^{23}} \times 197 = 3.6 \text{ g}$$

2. How many hydrogen atoms are in 5.37 g of $(NH_4)_3PO_4$?

A) 1.8×10^{23} B) 1.8×10^{24}
C) 2.2×10^{23} D) 2.6×10^{23}

SOLUTION

1 mol $(NH_4)_3PO_4$ contains 12 mol H

$\frac{5.37}{149}$ 0.036 mol $(NH_4)_3PO_4$ contains n mol H

$$N\ n = \frac{0.036 \times 12}{1} = 0.5326 \text{ mol}$$

$$N = n \times N_A = 0.5326 \times 6.022 \times 10^{23} = 2.6 \times 10^{23} \text{ atom}$$

3. How many moles are in 1.0 kg of pure table sugar $C_{12}H_{22}O_{11}$?

A) 2.92 B) 3.32 C) 3.64 D) 4.16

SOLUTION

$$n = \frac{m}{M} = \frac{1000}{342} = 2.92 \text{ mol}$$

4. The percentage by mass of nitrogen in $Bi(NO_3)_3$ is:

A) 7.36% B) 10.64% C) 8.54% D) 9.75%

SOLUTION

$$N = \frac{\text{mass of element}}{\text{mass of compound}} = \frac{42}{395} \times 100 = 10.6\%$$

5. The combustion of 1.031 g of an organic compound that contains only carbon, hydrogen and oxygen produced 2.265 g of CO_2 and 1.236 g of H_2O. What is the empirical formula of this compound?

A) C_2H_6O B) C_3H_5O C) C_3H_8O D) CH_2O

SOLUTION

$$C_{mass}\ \frac{M_{CO_2}}{M_C} \times m_{CO_2} = \frac{12}{44} \times 2.265 = 0.6177 \text{ g}$$

$$H_{mass}\ \frac{M_H}{M_{H_2O}} \times m_{H_2O} = \frac{2}{18} \times 10236 = 0.1373 \text{ g}$$

$$C_{mass} = M_{compound} - (C_{mass} +\_\ H_{mass}) = 1.031 - (0.6177 + 0.1373) = 0.276 \text{ g}$$

$$C : H : O$$

$$\frac{0.6177}{12} : \frac{0.1373}{1} : \frac{0.276}{16}$$

$$0.0515 : 0.1373 : 0.01725$$

3 : 8 : 1 C_3H_8O	

6. An element "X" combines with oxygen to form a compound with formula XO_2. If 6.7 g of this element combines with 3.9 g of oxygen, what is the atomic mass of this element (in a.m.u.)?

A) 55 B) 40 C) 65 D) 48

SOLUTION

$$X + O_2 \rightarrow XO_2$$

1 mol 1mol

n_x $\frac{3.9}{32} = 0.122$ mol

$$M_x = \frac{m_x}{n_x} = \frac{6.7}{0.122} = 55 \text{ AMU}$$

7. What is the theoretically yield (in grams) of copper Cu when 18.1 g of NH_3 gas and 90.4 g solid CuO were allowed to react according to:

$$2NH_3(g) + 3CuO(s) \rightarrow 3Cu(s) + N_2(g) + 3H_2O(g)$$

A) 48.7 B) 63.6 C) 68.5 D) 72.2

SOLUTION

$$2NH_3(g) + 3CuO(s) \rightarrow 3Cu(s) + N_2(g) + 3H_2O(g)$$

2 mol 3 mol

$\frac{18.1}{17} = 1.065$mol $\frac{90.4}{79.55} = 1.136$mol

$\frac{1.065}{2} = 0.532$ $\frac{1.136}{3} = 0.379$

CuO is the limiting reactant

$$2NH_3(g) + 3CuO(s) \rightarrow 3Cu(s) + N_2(g) + 3H_2O(g)$$

3 mol 3 mol

1.136 mol 1.136 mol

$$m_{Cu} = n_{Cu} \times M_{Cu} = 1.136 \times 63.55 = 72.2 \text{ g}$$

8. What is the percentage yield of lead (Pb) if 50.00 kg of PbO are reduced by heating with excess carbon and 40.75 kg of lead are produced according to:

$$PbO(s) + C(s) \rightarrow Pb(L) + CO(g)$$

A) 75.88% B) 87.79% C) 90.32% D) 94.65%

SOLUTION

$$PbO(s) + C(s) \rightarrow Pb(L) + CO(g)$$

1 mol 1 mol

$\frac{150000}{223.2} = 224$ mol 224 mol

$\frac{1.065}{2} = 0.532$ $\frac{1.136}{3} = 0.379$

$$\text{actual yield} = \frac{m_{Pb}}{M_{Pb}} = \frac{40750}{207.2} = 196.7 \text{ mol}$$

$$\text{yield percentage} = \frac{\text{actual yield}}{\text{teoretical yield}} \times 100 = \frac{196.7}{224} \times 100 = 87.8\%$$

9. How many milliliter of water must be added to a stock solution of 6.0M HNO_3 in order to prepare 900 mL of 0.5 M HNO_3 by dilution?

A) 825 B) 850 C) 780 D) 800

SOLUTION

$M_1 \times V_1 = M_2 \times V_2$

$V_1 = \frac{M_2 \times M_2}{M_1} = \frac{0.5 \times 900}{6} = 75 \text{ mL}$

$V_{H_2O} = V_2 - V_1 = 900 - 75 = 825 \text{ mL}$

10. What is the percent H_2SO_4 by mass in a 6.0 M H_2SO_4 solution that has a density of 1.34 g/mL?

A) 27.83% B) 32.74% C) 43.92% D) 78.25%

SOLUTION

$m_{H_2O} = n_{H_2O} \times M_{H_2O} = 6 \times 18 = 588 \text{ g}$

$m_{solution} = V_{solution} \times d_{solution} = 1000 \times 1.34 = 1340 \text{ g}$

$H_2SO_4\% = \frac{m_{H_2SO_4}}{m_{solution}} \times 100 = \frac{588}{1340} \times 100 = 43.88\%$

11. A sample of Cl_2 gas occupies a volume of 5.0 L at 25°C and 15.0 atm. What volume (in L) will this sample occupy at STP?

A) 68.7 B) 52.8 C) 40.6 D) 28.4

SOLUTION

$M_1 \times V_1 = M_2 \times V_2$

$\frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2}, V_2 = \frac{P_1 \times V_1 \times T_2}{P_2 \times T_1} = \frac{15 \times 5 \times 273}{1 \times 298} = 68.7 \text{ L}$

12. A tennis ball has an internal volume of 145 m-L and contains 0.366 g of N_2 gas. What will be the pressure (in atm) inside the ball at 25°C?

A) 1.8 B) 2.0 C) 2.2 D) 2.4

SOLUTION

$M_1 \times V_1 = M_2 \times V_2$

$P = \frac{n \times R \times T}{V} = \frac{\frac{m}{M} \times R \times T}{V} = \frac{\frac{0.366}{28} \times 0.0821 \times 298}{0.145} = 2.2 \text{ atm}$

13. What volume of oxygen gas at STP would be needed to react completely with 20.1 g of aluminum (Al) according to:

$$4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$$

A) 10.8 L B) 12.5 L C) 14.3 L D) 15.5 L

SOLUTION

$4Al(s)$	+	$3O_2(s)$	$\rightarrow$	$2Al_2O_3$
4 mol		3 mol		
$\frac{20.1}{26.98} = 0.745 \text{ mol}$		n		

$n = \frac{0.745 \times 3}{4} = 0.599 \text{ mol}$

$$V = \frac{n \times R \times T}{P} = \frac{\frac{m}{M} \times R \times T}{V} = \frac{0.599 \times 0.0821 \times 273}{1} = 12.25\ L$$

14. What is the molar mass (in $g.mol^{-1}$) of a certain gas if its density is 1.57 g/L at 25^oC and 1.2 atm?

A) 71 B) 44 C) 32 D) 28

SOLUTION

$$PM = dRT,\ M = \frac{d \times R \times T}{P} = \frac{1.57 \times 0.0821 \times 298}{1.2} = 32\ g/L$$

15. What is the root-mean-square speed of a neon Ne atom (in m/s) at 27^oC?

A) 450 B) 498 C) 585 D) 609

SOLUTION

$$\sqrt{\bar{U}^2} = \sqrt{\frac{3RT}{M}}\ \sqrt{\frac{3 \times 8.314 \times 300}{0.02018}} = 608.9\ m/s$$