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

1. **A piece of 155.0 g aluminum metal at 120°C was placed in a constant pressure calorimeter of negligible heat capacity containing 300.0 g of water at 20°C. Calculate the final temperature of the system (the aluminum metal and the water) in °C; given the specific heat of aluminum metal = 0.90 J/g °C, and that of water = 4.184 J/g °C.**

   A) 24 B) 26 C) 28 D) 30

SOLUTION

$q_1 = \square\ q_2$

$(m \times C_s \times \Delta t)_1 = \square\ (m \times C_s \times \Delta t)_2$

$155 \times 0.9 \times (t_2 - 120)_1 = \square\ 300 \times 4.184 \times (t_2 - 20)_2$

$t_2 -= 30$ °C

2. **A 2.2 g sample of quinone $C_6H_4O_2$ was burned in a bomb calorimeter for which the total heat capacity is 7850 J/°C. The temperature of the calorimeter increased from 23.44°C to 30.57°C. What is the molar heat of combustion of quinone (in kJ/mole)?**

   A) -2750 B) -2760 C) -2785 D) -2790

SOLUTION

$n = \frac{m}{M} = \frac{2.2}{108} = 0.0203$ mol

$\Delta T = T_1 - T2 = 30.57 - 23.44 = 7.13$ °C

$q = -C\ \Delta T = 7850 \times 7.13 = -55970$ J/0.0203 mol

$q\ = \frac{27571}{0.0203} = 2757114$ J/mol = 2757 kJ/mol

3. **Hydrazine, $N_2H_4(l)$ is used as a rocket fuel. The thermochemical equation for the combustion of hydrazine is:**

   $N_2H_4(L) + O_2(g) \rightarrow N_2(g) + 2H_2O(L)$ $\Delta H^\circ_{comb} = \square\ 662$ kJ

   How many grams of hydrazine are required to obtain 20654 kJ of heat energy?

   A) 800 B) 900 C) 1000 D) 1100

SOLUTION

$M_{C_2H_4} = 32$ g/mol

32 g N_2H_4 produces 662 kJ

$m_{C_2H_4}$ produces 20645 kJ

$m_{C_2H_4} = \frac{20654 \times 32}{662} = 998.4$ g

4. **From the enthalpies of the following reactions:**

   $2HF(g) \rightarrow H_2(g) + F_2(g)$ $\Delta H = 537$ kJ

   $2C(gr) + 2H_2(g) \rightarrow C_2H_4(g)$ $\Delta H = 52$ kJ

   $C(gr) + 2F_2(g) \rightarrow CF_4(g)$ $\Delta H = -680$ kJ

   Calculate (in kJ) ΔH for the following reaction:

   $C_2H_4(g) + 6F_2(g) \rightarrow 2CF_4(g) + 4HF(g)$

A) +2174 B) -2174 C) -2298 D) -2486

SOLUTION

$C_2H_4(g) \rightarrow 2C(s) + 2H_2(g)$	$\Delta H = \square\ 662$ kJ
$2C(s) + 4F_2(g) \rightarrow 2CF_4(g)$	$\Delta H = \square\ 1360$ kJ
$2H_2(g) + 2F_2(g) \rightarrow 4HF(g)$	$\Delta H = \square\ 1074$ kJ
$C_2H_4(g) + 6F_2(g) \rightarrow 2CF_4(g) + 4HF$	$\Delta H = \square\ 2486$ kJ

5. Given ΔH_f°,$NH_3(g)$ = -46 kJ/mol. Calculate (in kJ) the change in internal energy, DE°, for the following reaction:

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

A) -51 B) -41 C) -87 D) -97

SOLUTION

ΔH_f°,$NH_3(g)$ = 2 × □ 64 = - 92 kJ/ 2 mol

$\Delta E = \Delta H^{\circ} - RT\Delta(\Delta n_g)$

$\Delta E = -92 - \frac{8.314}{1000} \times 298 \times -2 = 87.4$ kJ

6. The solubility of nitrogen gas in water at 25°C and its partial pressure at 0.76 atm is 5.2×10^{-4} mol/L. What is the partial pressure of nitrogen (in atm) at which its solubility in water is 1.71×10^{-3} mol/L at 25°C?

A) 2.7 B) 2.5 C) 2.3 D) 2.1

SOLUTION

$\frac{C_1}{C_2} = \frac{P_1}{P_2}$, $P_2 = \frac{C_2 \times P_1}{C_1} = \frac{1.71 \times 10^{-3} \times 076}{5.2 \times 10^{-4}} = 2.5$ atm

7. Benzene, C_6H_6, and toluene, C_7H_8, form ideal solution that has a total vapor pressure of 1.0 atm. What is the mole fraction of benzene in this solution, knowing that the vapor pressure of pure benzene is 1.326 atm and that of pure toluene is 0.532 atm? (all vapor pressures given are measured at exactly the same temperature).

A) 0.56 B) 0.59 C) 0.62 D) 0.64

SOLUTION

$P_T = 1 = X_1P_1 + X_2P_2 = \{X_1P_1\} + \{1 - X_1\}P_2 = \{X_1 \times 10326\} + \{(1 - X_1) \times 0.532\}$

$X_1 = 0.59$

8. A solution containing 10.0 g of $CaCl_2$ (an electrolyte) in 100.0 g of water freezes at -4.1°C. What is the vant Hoff factor of this solution? (K_f water = 1.86 °C/m).

A) 2.85 B) 2.68 C) 2.59 D) 2.45

SOLUTION

$\Delta T_f = i\times\left(\frac{K_f \times m_2 \times 1000}{M_2 \times m_1}\right)$, $4.1 = i \times \left(\frac{1.86 \times 10 \times 1000}{110.98 \times 100}\right)$, $i = 2.45$

9. A solution prepared from 100.0 g of non-volatile non-electrolyte solute in 5.5 mole of toluene (C_7H_8) has a vapor pressure of 0.161 atm at 60°C. What is the molecular weight (in g/mole) of the solute knowing that the vapor pressure of pure toluene at 60°C is 0.184 atm?

A) 127.3 B) 132.5 C) 145.6 D) 154.8

SOLUTION

$P_{solvent} = 0.161 = X_{solvent} P_1 \; P^{\circ}_{solvent} = X_{solvent} \times 0.1840, \; X_{solvent} = 0.875$

$X_{solvent} = \frac{n_{solvent}}{n_{solvent} + n_{solute}}, \; 0.875 = \frac{5.5}{5.5 + n_{solute}}, \; n_{solute} = 0.7857 \text{ mol}$

$M_{solute} = \frac{m_{solute}}{n_{solute}} = \frac{100}{0.7857} = 127.3 \text{ g/mol}$

10. The molar mass of hemoglobin (a non-electrolyte) is 6.8×10^4 g/mole. What is the osmotic pressure (in mmHg) at 27°C of a solution of 8.0 g hemoglobin in 200 mL of water?

A) 9.0 B) 11.0 C) 13.0 D) 14.0

SOLUTION

$\Pi \times V = \frac{m}{M} \times R \times T$

$\Pi \times \frac{200}{1000} = \frac{8}{6.8 \times 10^4} \times 0.0821R \times 300, \; \Pi = 0.0145 \text{ atm} = 11 \text{ mmHg}$

11. For the hypothetical reaction

$$A + 3B \rightarrow 2C$$

the rate of appearance of C given by $\left(\frac{\Delta[C]}{\Delta t}\right)$ may be also expressed as:

A) $+\frac{3\Delta[B]}{2\Delta t}$ B) □ $\frac{3\Delta[B]}{2\Delta t}$ C) $-\frac{2\Delta[B]}{3\Delta t}$ D) $+\frac{2\Delta[B]}{3\Delta t}$

SOLUTION

$-\frac{\Delta[A]}{\Delta t} = -\frac{\Delta[B]}{3\Delta t} = +\frac{\Delta[C]}{2\Delta t}, \; -\frac{\Delta[C]}{\Delta t} = -\frac{2\Delta[A]}{\Delta t} = -\frac{2\Delta[C]}{3\Delta t}$

12. The data in the table below were obtained for the reaction:

$$2NO + H_2 \rightarrow N_2O + H_2O$$

Exp.	$[NO]_o$ (M)	$[H_2]_o$ (M)	Initial rate (M/s)
1	0.273	0.763	2.83
2	0.273	1.526	2.83
3	0.819	0.763	25.47

the rate law for this reaction is: rate =

A) $k[NO]^2[H_2]$ B) $k[NO][H_2]^2$
C) $k[NO]^2[H_2]^2$ D) $k[NO]^2$

SOLUTION

rate = k[NO]^x[H$_2$]^2

$\frac{rate_3}{rate_1} = \frac{k\,[NO_2]_3^x[H_2]_3^x}{k\,[NO_2]_1^x[H_2]_1^x} = \frac{25.47}{2.83} = (\frac{0.819}{608})^x$, 9 = 3^x, x = 2

$\frac{rate_2}{rate_1} = \frac{k\,[NO_2]_2^y[H_2]_2^y}{k\,[NO_2]_1^y[H_2]_1^y} = \frac{2.83}{2.83} = (\frac{1.526}{0.763})^y$, 1 = 2^y, y = 0

rate = k[NO]^2

13. A compound decomposes by a first-order process. If 25% of the compound decomposes in 61.0 minutes, what is the half life (in minutes) of this decomposition reaction?

A) 142 B) 147 C) 152 D) 160

SOLUTION

$\ln \frac{[A]_o}{[A]_t} = kt$, $\ln \frac{100}{75} = k \times 61$, $k = 4.7 \times 10^{-3}\ min^{-1}$

$t_{0.5} = \frac{\ln 2}{k} = \frac{0.693}{4.7 \times 10-3} = 147$ min

14. The isomerization of cyclopropane to form propene follow a first-order kinetics. At 700 K, 10% of a sample of cyclopropane is isomerized to propene in 170 minutes. How many minutes are required for 35% of a sample of cyclopropane to change to propene at 700 K?

A) 695 B) 675 C) 625 D) 595

SOLUTION

$\ln \frac{[A]_o}{[A]_t} = kt$, $\ln \frac{100}{90} = k \times 170$, $k = 6.2\times 10^{-4}\ min^{-1}$

$t = \frac{\ln \frac{100}{65}}{k} = \frac{0.693}{6.2\times 10-4} = 694.8$ min

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

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

SOLUTION

$\ln \frac{k_2}{k_1} = \frac{E_a}{R}$ Ea $- (\frac{T_2 - T_1}{T_1 \times T_2})$, $\ln \frac{5.5 \times 10^{-2}}{4.3 \times 10^{-2}} = \frac{E_a}{8.314 \times 10^3} - (\frac{503 - 472}{472 \times 503})$, $E_a = 162.28$ kJ

$k \times 170$, $k = 6.2\times 10^{-4}\ min^{-1}$