REVIEW AND PRACTICE 3

ANSWERS

1. $V_{H_2O} = 150 \text{ mL}$

$T_1 = 21.6°C$

$T_2 = 15.2°C$

$q = ?$

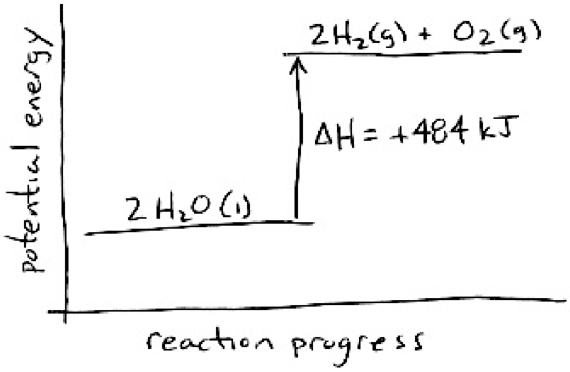
$$q = mc\Delta T$$
$$= mc(T_2 - T_1)$$
$$= (150 \text{ g})\left(4.18 \frac{J}{g°C}\right)(15.2°C - 21.6°C)$$
$$= (150 \cancel{g})\left(4.18 \frac{J}{\cancel{g}°\cancel{C}}\right)(-6.4°\cancel{C})$$
$$= -4012.8 \text{ J}$$

∴ The water lost 4.0 kJ of thermal energy.

2. (a) endothermic

(b) $$\Delta H_{rxn} = \frac{\Delta H}{n} = \frac{+484 \text{ kJ}}{2 \text{ mol } H_2O}$$
$$= +242 \text{ kJ/mol } H_2O$$

(c)



3. $2\ H{-}Cl \rightarrow H{-}H + Cl{-}Cl$

$H{-}Cl$ 2 mol @ +427 kJ/mol

$H{-}H$ 1 mol @ −432 kJ/mol

$Cl{-}Cl$ 1 mol @ −239 kJ/mol

$$\Delta H = 2\cancel{mol}\left(+427\frac{kJ}{\cancel{mol}}\right) + 1\cancel{mol}\left(-432\frac{kJ}{\cancel{mol}}\right) + 1\cancel{mol}\left(-239\frac{kJ}{\cancel{mol}}\right)$$

$$= +183\ kJ$$

∴ The enthalpy change for the reaction is +183 kJ.

4. $$4\ NH_3(g) + 5\ O_2(g) \longrightarrow 4\ NO(g) + 6\ H_2O(g)$$

$\Delta H_f =$ $-45.9\frac{kJ}{mol}$ $0\frac{kJ}{mol}$ $+90.2\frac{kJ}{mol}$ $-241.8\frac{kJ}{mol}$

$$\Delta H = \sum n\cdot\Delta H_{f\,(products)} - \sum n\,\Delta H_{f\,(reactants)}$$

$$= \left[4\cancel{mol}\left(+90.2\frac{kJ}{\cancel{mol}}\right) + 6\cancel{mol}\left(-241.8\frac{kJ}{\cancel{mol}}\right)\right] - \left[4\cancel{mol}\left(-45.9\frac{kJ}{\cancel{mol}}\right)\right]$$

$$= (-1090\ kJ) - (-183.6\ kJ)$$

$$= -906.4\ kJ$$

∴ The enthalpy change for the reaction is −906.4 kJ.

5. ② $\times -1$ $P_4O_{10}(s) \rightarrow \cancel{P_4}(s) + 5\cancel{O_2}(g)$ $\Delta H = (-1)(-2967\,kJ)$

③ $\times -6$ $6\,PCl_5(g) \rightarrow 6\,\cancel{PCl_3}(g) + 6\,\cancel{Cl_2}(g)$ $\Delta H = (-6)(-84\,kJ)$

④ $\times +5$ $10\,\cancel{PCl_3}(g) + 5\,\cancel{O_2}(g) \rightarrow 10\,POCl_3(g)$ $\Delta H\ (+5)(-572\,kJ)$

① $\times +1$ $\cancel{P_4}(s) + 6\,\cancel{Cl_2}(g) \rightarrow 4\,\cancel{PCl_3}(g)$ $\Delta H = (+1)(-1226\,kJ)$

$$P_4O_{10}(s) + 6\,PCl_5(g) \longrightarrow 10\,POCl_3(g)$$

$$\Delta H = (-1)(-2967\,kJ) + (-6)(-84\,kJ) + (5)(-572\,kJ) + (1)(-1226\,kJ)$$
$$= -615\,kJ$$

∴ The enthalpy change for the reaction is −615 kJ.

6. (a) exothermic

(b) 200 kJ

(c) 500 kJ

(d) −300 kJ

(e) $XY + Z \rightarrow XZ + Y + 300\,kJ$

7. (a) $A_2 + C_2 \longrightarrow 2AC$

(b) A_2B , A_2C_2

(c) B

8. $q = mc\Delta T$

assuming the solution has the same density as water

$$= (150.0\,g)\left(4.18\frac{J}{g^\circ C}\right)(29.1^\circ C - 26.0^\circ C)$$

$$= 1943.7\ J$$

assuming the solution has the same heat capacity as water

$\Delta H = -q$ ←(assuming the system is isolated

$$= -1943.7\ J$$

$$n_{Ba(NO_3)_2} = \frac{m}{MM}$$

$$= \frac{19.6\ g}{261.35\ \frac{g}{mol}}$$

$$= 0.074995\ldots\ mol$$

$$\Delta H_r = \frac{-1943.7\ J}{0.074995\ldots\ mol}$$

$$= -25917.65\ldots\ \frac{J}{mol}$$

$$= -26\ kJ/mol$$

9.

$$4\,NH_{3(g)} + 7\,O_{2(g)} \longrightarrow 4\,NO_{2(g)} + 6\,H_2O_{(g)}$$

$$\Delta H_f = \quad -45.9\,\tfrac{kJ}{mol} \qquad 0 \qquad +33.2\,\tfrac{kJ}{mol} \qquad -241.8\,\tfrac{kJ}{mol}$$

① FOR REACTION → $\Delta H = \left[4\,\text{mol}\left(+33.2\,\frac{kJ}{mol}\right) + 6\,\text{mol}\left(-241.8\,\frac{kJ}{mol}\right)\right] - \left[4\,\text{mol}\left(-45.9\,\frac{kJ}{mol}\right)\right]$

$= -1134.4\ kJ$

② $\Delta H_{COMB} = \dfrac{-1134.4\ kJ}{4\ mol\ NH_3}$

$= -283.6\ kJ/mol\ NH_3$

③ $n_{NH_3} = \dfrac{m}{MM}$

$= \dfrac{1.0\ g}{17.04\ \frac{g}{mol}}$

$= 0.058685\ldots\ mol$

④ FOR 1.0 g NH_3 → $\Delta H = n \cdot \Delta H_r$

$= (0.058685\ldots mol)\left(-283.6\ \frac{kJ}{mol}\right)$

$= -16.643\ldots\ kJ$

∴ 17 kJ are release when 1.0 g of NH_3 reacts with oxygen.

10. ① Find molar enthalpy change for reaction.

$$CH_4(g) + 2\,O_2(g) \rightarrow CO_2(g) + 2\,H_2O\,(g)$$

$$\Delta H = \sum n \cdot \Delta H_{f\,(\text{products})} - \sum n \cdot \Delta H_{f\,(\text{reactants})}$$

$$= \left[1\cancel{\text{mol}}\left(-393.5\frac{\text{kJ}}{\cancel{\text{mol}}}\right) + 2\cancel{\text{mol}}\left(-241.8\frac{\text{kJ}}{\cancel{\text{mol}}}\right)\right] - \left[1\cancel{\text{mol}}\left(-74.4\frac{\text{kJ}}{\cancel{\text{mol}}}\right)\right]$$

$$= -802.7 \text{ kJ}$$

$$\Delta H_{\text{COMB}} = \frac{\Delta H}{n} = \frac{-802.7 \text{ kJ}}{1 \text{ mol } CH_4} = -802.7 \text{ kJ/mol } CH_4$$

② Find enthalpy change required

boiling point for water

$$q = mc\Delta T$$

$$= (2000\,g)\left(4.18\,\frac{J}{g\,°C}\right)(100.0°C - 20.0°C)$$

$$= (2000\,\cancel{g})\left(4.18\,\frac{J}{\cancel{g}\,\cancel{°C}}\right)(80.0\cancel{°C})$$

$$= 668800 \text{ J} = 668.8 \text{ kJ}$$

$$\Delta H = -q$$ ← assuming all heat transferred to the water

$$= -668.8 \text{ kJ}$$

③ Find mass of CH_4 required

$$n_{CH_4} = \frac{\Delta H}{\Delta H_{\text{COMB}}} = \frac{-668.8\,\cancel{\text{kJ}}}{-802.7\,\cancel{\text{kJ}}/\text{mol}} = 0.83318\ldots \text{ mol}$$

$$m_{CH_4} = n_{CH_4} \cdot M_{CH_4} = (0.83318\ldots\,\cancel{\text{mol}})\left(16.05\,\frac{g}{\cancel{\text{mol}}}\right) = 13.3\ldots g$$

∴ A minimum of 13 g of methane is required.

11.

① Find heat transfer

(from equation)

$$\Delta H_{sol} = \frac{\Delta H}{n} = \frac{+26\,kJ}{1\,mol\,NH_4NO_3} = +26\,\frac{kJ}{mol\,NH_4NO_2}$$

$$n_{NH_4NO_3} = \frac{m}{M} = \frac{10.0\,\cancel{g}}{80.06\,\frac{\cancel{g}}{mol}} = 0.1249\ldots\,mol$$

(for 10g) →

$$\Delta H = n \cdot \Delta H_{sol}$$
$$= (0.1249\ldots\,\cancel{mol})\left(+26\,\frac{kJ}{\cancel{mol}}\right)$$
$$= 3.2475\ldots\,kJ$$

$$q = -\Delta H$$ ← (assuming the system is isolated)

$$= -3.2475\ldots\,kJ$$

② Find final temperature, T_2

$$q = mc\Delta T$$
$$= mc(T_2 - T_1)$$

$$T_2 = \frac{q}{mc} + T_1$$
$$= \frac{-3247.5\ldots\,\cancel{J}}{(100.0\,\cancel{g})(4.18\,\frac{\cancel{J}}{g°C})} + 20.0°C$$
$$= -7.769\ldots°C + 20.0°C$$
$$= 12.23\ldots°C$$

∴ The final temperature of the water is 12.2 °C