AP Chem Unit 11 Thermodynamics

Super Problem : Thermodynamics

① $Mg_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$ $\Delta H_{rxn} = -316.0\ \frac{KJ}{mol}$

Mg: 0.650g; HCl: 1.0M, 50.0ml

A) ? Heat released

$\left(\frac{0.650g\ Mg}{1}\right)\left(\frac{1 mole\ Mg}{24.31g\ Mg}\right)\left(\frac{316.0\ KJ}{1 mole *}\right) = \boxed{8.45\ KJ}$

B) $q = mC\Delta T$ $\Delta T = ?$

$q = 8.45KJ = 8450J$

$C = 4.18\ J/g°C$

m = mass HCl + Mg ⇒ 50g + 0.650g = 50.7g

50ml HCl ≈ 50g

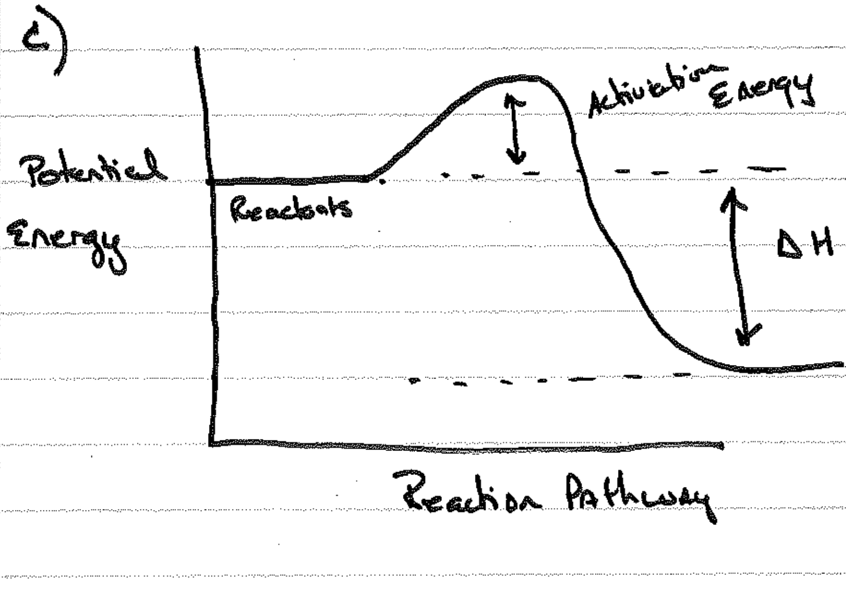
1 ml H_2O = 1g

$\Delta T = \frac{q}{mC}$

$= \frac{8450J}{(50.7g)(4.18\ \frac{J}{g°C})}$

$\boxed{\Delta T = 39.9°}$

C)



* $-3160\ \frac{KJ}{mole}$

* ∴ Exo

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2/5

d) $Mg_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$ $\Delta H = -3160 \frac{kJ}{mol}$

$V_1 = 650\ mL$
1.0 Atm
$\Delta T = 15°C$
$V_2 = 620\ mL$

Is TEMP of system ↑ or ↓ ??

The Temperature of system is <u>decreasing</u>.

Reason → must have: A decrease in volume of gas indicates a decrease in the temperature of the gas the system is at <u>Constant Pressure</u> and the <u>amount of the</u> gas is not changing

e) Work done? (J)

$w = -P\Delta V$ $P = 1.0\ Atm$

$= -(1.0 Atm)(-30 mL)$

$= +30\ Atm \cdot mL$ $\Delta V = V_2 - V_1 = 620\ mL - 650\ mL = -30\ mL$

want in J

$$\left(\frac{+30\ Atm \cdot mL}{1}\right)\left(\frac{1\ L}{1000\ mL}\right)\left(\frac{101.3\ J}{1\ L \cdot Atm}\right) = \boxed{3.04\ J}$$

f) The statement is wrong. A decrease (-30 mL) in the volume of gas indicates the surroundings are doing work on the system.

NMSI Super Problem : Thermodynamics

g) ΔH_{rxn} = ?

$$Mg_{(s)} + \frac{1}{2} O_{2(g)} \rightarrow MgO_{(s)}$$

Given:

	KJ/mol
$Mg_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$	$\Delta H^\circ_{rxn} = -316.0$
$MgO_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_2O_{(l)}$	$\Delta H^\circ_{rxn} = -45.7$
$H_{2(g)} + \frac{1}{2} O_{2(g)} \rightarrow H_2O_{(l)}$	$\Delta H_{rxn} = -286$

Soln.

same	$H_{2(g)} + \frac{1}{2} O_2 \rightarrow H_2O_{(l)}$	-286
R	$H_2O_{(l)} + MgCl_{2(aq)} \rightarrow MgO_{(s)} + 2HCl_{(aq)}$	$+45.7$
same	$Mg_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$	-316.0

$$Mg_{(s)} + \frac{1}{2} O_2 \rightarrow MgO_{(s)} \qquad \Delta H^\circ_{rxn} = -556 \frac{KJ}{mol}$$

H) $Mg_{(s)} + \frac{1}{2} O_2 \longrightarrow MgO$ $\quad \Delta S^\circ_{Rxn}$ = ?

Mg: 33 J/mol K; O_2: 205 J/mol K; MgO: 27 J/mol K

$$\Delta S^\circ_{Rxn} = \sum \Delta S^\circ_P - \sum \Delta S^\circ_R$$

$$= 1\frac{mol}{mol\,Rxn}\left(27 \frac{J}{mol\,K}\right) - \left[\frac{1\,mol}{mol\,Rxn}(33\ J/mol\,K) + \frac{1\,mole}{2\,mol\,Rxn}\left(205 \frac{J}{mol\,K}\right)\right]$$

$$= 27 \frac{J}{mol\,K} - 136 \frac{J}{mol\,K}$$

$$\Delta S^\circ_{Rxn} = -109 \frac{J}{mol_{Rxn}\,K}$$

Super Problem : Thermodynamics

I) ΔG°_{Rxn} = ? Mg @ 25° T = 273 + 25 = 298

$\Delta^\circ G = \Delta H^\circ - T\Delta S^\circ$

$= -556 \frac{KJ}{mol} - (298K)\left(\frac{-109 J}{mol\ K}\right)\left(\frac{1 KJ}{1000 J}\right)$

$= -556\ KJ/mol + 32.5\ KJ/mol$

$\boxed{\Delta G^\circ = -524\ KJ/mol}$

J) Is Reaction thermodynamically favored @ 25°C ?

* Since ΔG° is Negative the Reaction is thermodynamically favored

K) Given: $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

$\Delta G^\circ_{Rxn} = -34.1 \frac{KJ}{mol}$

$\Delta H^\circ_{Rxn} = -92.2 \frac{KJ}{mol}$

find: K = ?

Soln: Since the Reaction is Thermodynamically favored

(i) (ΔG° is Neg) the equilibrium constant will Be > 1 as the products are favored

(ii) $\Delta G^\circ = -RT \ln K_{eq}$

$\ln K_{eq} = \frac{-\Delta G}{RT} = \frac{(-34.1 \frac{KJ}{mol})}{(8.3145 \frac{J}{mol \cdot K})(\frac{1 KJ}{1000 J})(298 K)}$

$\ln K_{eq} = 13.8$

$\boxed{K_{eq} = 9.85 \times 10^5}$

L) (i) $\Delta S°$ sign for $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

Soln:

4 moles gas converted to 2 moles gas

∴ The Reaction will Become less disordered (more organized)

∴ $-\Delta S$

(ii) $\Delta S = ?$

$$\Delta G° = \Delta H° - T\Delta S$$

$$\Delta S = \frac{\Delta H° - \Delta G°}{T} = \frac{\left(-92.2\frac{KJ}{mol} - (-34.1\frac{KJ}{mol}\right)}{298\,K}$$

$$\boxed{\Delta S = -.195\ \frac{KJ}{mol\,K} \text{ or } \frac{-195\,J}{mol\,K}}$$

m) $\Delta H°_{Rxn} = -92.2\frac{KJ}{mol}$

	$N_{2(g)}$ +	$3H_{2(g)}$ $\rightleftharpoons$	$2NH_{3(g)}$
Bond Energy	$960\frac{KJ}{mol}$	$430\frac{KJ}{mol}$	? Bond Energy

$\Delta H°_{Rxn} = \Sigma$ Bonds Broken $- \Sigma$ Bonds formed (coeff, NH_3)

$$-92.2\frac{KJ}{mol} = \left[\left(960\frac{KJ}{mol}\right) + 3\left(430\frac{KJ}{mol}\right)\right] - \left[2\left(3X\right)\right]$$

$$-92.2\frac{KJ}{mol} = 2250\frac{KJ}{mol} \quad -6X$$

$$-2342\frac{KJ}{mol} = -6X$$

$$\boxed{X = 390\ KJ/mol}$$

x = N-H Bond