1) ANS: C

Calculate what you need the $[F^-]$ concentration to become when $[Pb^{2+}]$ is equal to 1×10^{-6} molar.

$K_{sp} = [Pb^{2+}][F^-]^2 = 4.0 \times 10^{-8} = [1 \times 10^{-6}][F^-]^2$ therefore, $[F^-]^2 = 4 \times 10^{-2} = 0.04$, take the square root and you get $[F^-] = 0.20$ molar which requires 0.20 moles of NaF in a 1.00 L of solution. The amount of F^- already present in the solution is negligible since the K_{sp} is so small to begin with.

Recognize that this question will take a lot of time which makes it a candidate for guessing!

DIF: Hard OBJ: 6.23 TOP: Equilibrium MSC: 1984 #74
NOT: 20% answered correctly

2) ANS: A

Note that you were told the equilibrium amount of SO_3. Use it to work out the entire equilibrium line of the RICE table.

R	$2\,SO_2(g)$ +	$O_2(g)$ ⇆	$2\,SO_3(g)$	
I	0.40	0.60	0	
C	$-2x$	$-x$	$+2x$	
E	*0.10	*0.45	0.30	*so, $2x = 0.30$, so $x = 0.15$

$$K = \frac{[SO_3]^2}{[O_2][SO_2]^2} = \frac{[0.30]^2}{[0.45][0.10]^2}$$

DIF: Hard OBJ: 6.5 TOP: Equilibrium MSC: 1994 #73
NOT: 24% answered correctly

3) ANS: B

$\Delta H < 0$; thus it is a negative value, therefore the reaction is exothermic, so think of the reaction as:

$$2\,NO(g) + O_2(g) \leftrightharpoons 2\,NO_2(g) + \textit{heat}$$

Thus, adding heat (increasing the temperature) shifts the reaction to the left (reactants favored) decreasing the value of K_{eq}.

DIF: Hard OBJ: 6.8 TOP: Equilibrium MSC: 1999 #54
NOT: 35% answered correctly

4) ANS: D

$Ag_2CrO_4 \rightleftarrows 2\ Ag^+ + CrO_4^{2-}$

The molar solubility is the concentration in moles/L of the salt that dissolves so it is equal to x and equal to $[CrO_4^{2-}]$.

Therefore, $K_{sp} = [Ag^+]^2[CrO_4^{2-}] = [2x]^2[x] = 4x^3 = 8 \times 10^{-12}$

$$\therefore x^3 = \frac{8 \times 10^{-12}}{4} = 2 \times 10^{-12}$$

$$\therefore x = \sqrt[3]{2 \times 10^{-12}}\ M$$

$= 4 \times 10^{-12}$

DIF: Hard OBJ: 6.22 TOP: Equilibrium MSC: 1999 #67
NOT: 25% answered correctly

5) ANS: A

Expect easy math!

$Zn(OH)_2 \rightarrow Zn^{2+} + 2\ OH^-$ therefore, $K_{sp} = [Zn^{2+}]\ [OH^-]^2 = [x][2x]^2 = 4x^3$

If $[OH^-] = 2x = 2.0 \times 10^{-6}\ M$, then $x = 1.0 \times 10^{-6}\ M$ plug in those values and solve.

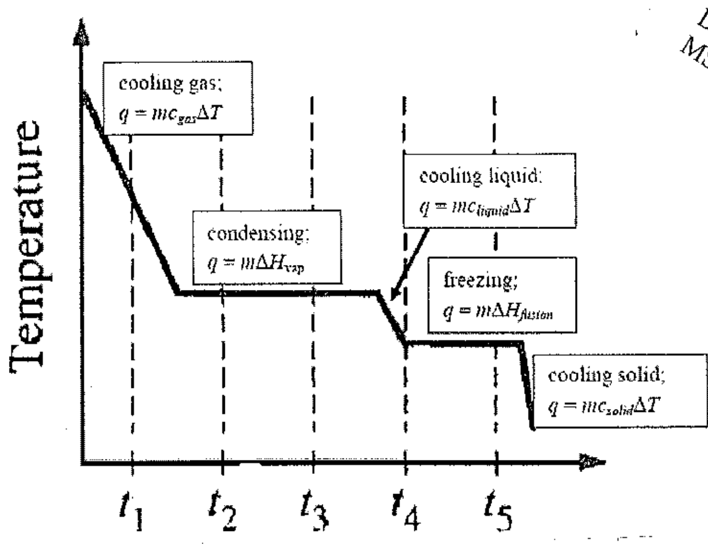
$K_{sp} = [1.0 \times 10^{-6}][2.0 \times 10^{-6}]^2 = 4.0 \times 10^{-18}$

DIF: Hard OBJ: 6.22 TOP: Equilibrium MSC: 2002 #75
NOT: 21% answered correctly

6) ANS: D

Realize the "slants" represent temperature changes during which the entire sample is in a single phase. The "plateaus" represent a single temperature during which a phase change is taking place and the two phases are in *equilibrium*.

So, the "most liquid" will be present during t_4 since that time involves the cooling of the liquid (a "slant") whereas t_1 represents a time when the gas is cooling. Additionally, t_2 and t_3 represent times when an equilibrium mixture of gas and liquid are present at constant temperature (Condensation Pt $\rightleftarrows$Boiling Pt) and t_5 represents a time when an equilibrium mixture of liquid and solid are present at constant temperature (FP$\rightleftarrows$MP).



DIF: Medium OBJ: 6.9 TOP: States of Matter MSC: 2008 #45
NOT: 57% answered correctly

AP Chem - Unit 9 - Review II

3/3

7) ANS: B

Focus on the balanced equation to get the equilibrium expression, then the diagram to get the "concentrations".

$K = \frac{[N_2O_4]}{[NO_2]^2}$, so figure out the initial "concentrations": 3 funky white blobs = N_2O_4 and 6 black dots = NO_2, so

$K = \frac{[3]}{[6]^2} = \frac{3}{36}$ which is less than 1

DIF: Hard OBJ: 6.5 TOP: Equilibrium MSC: 2008 #59
NOT: 32% answered correctly

8) ANS: A

Classic LeChatlier! Adding Gas B shifts the equilibrium left (favors the reactant) and takes Gas C kicking and screaming with it to form more of Gas A. So, the concentration of Gas C decreases. The value of the equilibrium constant remains constant until there is a change in temperature.

DIF: Easy OBJ: 6.8 MSC: Conceptual

9) ANS: C

When Q, the reaction quotient exceeds the K_{sp} value a precipitate forms.

DIF: Easy OBJ: 6.4 | 6.21 TOP: Solubility Equilibrium

10) ANS: D

Equilibrium results when the forward reaction proceeds at the same rate as the reverse reaction. Catalysts speed up chemical reactions, so the equilibrium may be reached quicker but catalysts cannot change the equilibrium position.

DIF: Easy OBJ: 6.1 | 6.3 MSC: Conceptual

Key 1/10

Wkst: Unit 9 Review II

$$2\,H_2S(g) \rightleftharpoons 2\,H_2(g) + S_2(g)$$

#1) When heated, hydrogen sulfide gas decomposes according to the equation above. A 3.40 g sample of $H_2S(g)$ is introduced into an evacuated rigid 1.25 L container. The sealed container is heated to 483 K, and 3.72×10^{-2} mol of $S_2(g)$ is present at equilibrium.

(a) Write the expression for the equilibrium constant, Kc , for the decomposition reaction represented above. (1pt)

$$K_c = \frac{[S_2][H_2]^2}{[H_2S]^2}$$

(b) Calculate the equilibrium concentration, in mol L^{-1}, of H_2 and H_2S in the container at 483 K. (3pts)

	$2\,H_2S$ ⇋	$2\,H_2$	S_2
I	.0798 M	0	0
	$-2x$	$+2x$	x
E	.0798 − 2(.0298)		x = .0298 M

$\left(3.40\text{g } H_2S\right)\left(\frac{1\text{ mole } H_2S}{34.08\text{g } H_2S}\right)\left(\frac{1}{1.25L}\right) = .0798$ M H_2S

$\frac{3.72\times10^{-2}\text{ mole } S_2}{1.25L} = .0298$ M

$[H_2S] = .0202$ M $[H_2] = 2(.0298)$ $[H_2] = .0596$ M $[S_2] = .0298$ M

(c) Calculate the value of the equilibrium constant, Kc , for the decomposition reaction at 483 K. (1pt)

$$K_c = \frac{[.0298][.0596]^2}{[.0202]^2} = .259$$

(d) Calculate the partial pressure of $S_2(g)$ in the container at equilibrium at 483 K. (1pt)

P = ? $n_s = 3.72\times10^{-2}$ m $PV = nRT$

V = 1.25 L

R = .0821 $P = \frac{nRT}{V}$

T = 483

$$P = \frac{(3.72\times10^{-2})(.0821)(483)}{1.25}$$

P = 1.18 Atm

(e) For the reaction $H_2(g) + \frac{1}{2}S_2(g) \rightleftharpoons H_2S(g)$ at 483 K, calculate the value of the equilibrium constant, Kc (1pt)

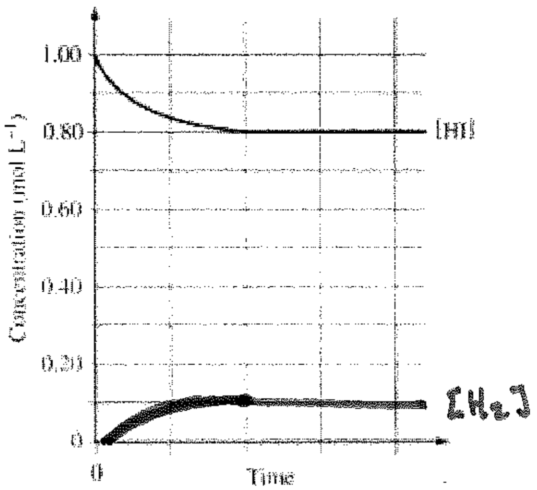
$$K_c' = \frac{1}{\sqrt{K_c}} = \frac{1}{\sqrt{.259}}$$

$K_c' = 1.96$

$2\,HI(g) \leftrightarrows H_2(g) + I_2(g)$

Key 2/3

#2) After a 1.0 mole sample of HI(g) is placed into an evacuated 1.0 L container at 700. K, the reaction represented above occurs. The concentration of HI(g) as a function of time is shown below.



(a) What is [HI] at equilibrium? (1pt)

From graph [HI] equilibrium = .80 M

(b) It is determined that 0.10 mol of $H_2(g)$ is present at equilibrium. On the graph above, make a sketch on your answer pages that shows how the concentration of $H_2(g)$ changes as a function of time. (2pt)

.10 mole H_2 @ Equilibrium — on Graph

(c) Calculate the value of Kp and Kc equilibrium constants at 700. K. (4pt)

	HI →	H_2	I_2
E	.8	.1	x

x = .1

$$K_c = \frac{[H_2][I_2]}{[HI]^2} = \frac{(.1)(.1)}{(.8)^2} = .016$$

$$K_p = K_c(RT)^{\Delta n}$$

$$= (.016)(RT)^0$$

$$(.016)(1)$$

$K_p = .016$

n = # mole P(g) − # mole R(g)

= 2 − 2

= 0

Key 3/3

#3) A sample of solid U_3O_8 is placed in a rigid 1.500 L flask. Chlorine gas, $Cl_2(g)$, is added, and the flask is heated to 862°C. The equation for the reaction that takes place and the equilibrium-constant expression for the reaction are given below.

$$U_3O_8(s) + 3\,Cl_2(g) \rightleftharpoons 3\,UO_2Cl_2(g) + O_2(g) \qquad K_p = \frac{(P_{UO_2Cl_2})^3(P_{O_2})}{(P_{Cl_2})^3}$$

? Atm

Flask = 1.500 L
T = 862°C

When the system is at equilibrium, the partial pressure of $Cl_2(g)$ is 1.007 atm and the partial pressure of $UO_2Cl_2(g)$ is 9.734×10^{-4} atm.

P_{Cl_2} = 1.007 Atm
$P_{UO_2Cl_2}$ = 9.734×10^{-4} Atm
P_{O_2} = ?

A) Calculate the partial pressure of $O_2(g)$ at equilibrium at 862°C. (2pt)

	$3Cl_2$	⇌	$3UO_2Cl_2$	+ O_2
I				
C	3x		3x	x
E	1.007		9.734×10^{-4}	x

$3x = (9.734 \times 10^{-4}\text{ Atm})$ $\boxed{x = 3.245 \times 10^{-4}\text{ Atm}}$ PO_2

B) Calculate the value of the equilibrium constant, Kp, for the system at 862°C. (2pt)

$$K_p = \frac{(P_{UO_2Cl_2})^3\,P_{O_2}}{(P_{Cl_2})^3} = \frac{(9.734 \times 10^{-4})^3\,(3.245 \times 10^{-4})}{(1.007)^3}$$

$$\boxed{K_p = 2.93 \times 10^{-13}}$$

C) After a certain period of time, 1.000 mol of $O_2(g)$ is added to the mixture in the flask. Does the mass of $U_3O_8(s)$ in the flask increase, decrease, or remain the same? Justify your answer. (2pt)

The mass of $U_3O_8(s)$ will increase, Because if you add more products ($O_2(g)$) this will cause the Rxn to shift to the left to correct equilibrium Resulting in more Reactants.

Key

4) Solve the following problem related to the solubility equilbria of some metal hydroxides in aqueous solutions.

a) The solubility of $Cu(OH)_2$ (s) is 1.72 x 10^{-6} g/100ml of solution at 25°C

i) Write the balanced chemical equation for the dissociation of $Cu(OH)_2$ in aqueous solution

ii) Calculate the value of Ksp for $Cu(OH)_2$ at 25°C

b) The value of Ksp for $Zn(OH)_2$ is 7.7 x 10^{-17} at 25°C

i) If 50.0 ml of .100M $ZnCl_2$ is mixed with 50.0 ml of 0.300M Na(OH). Will a precipitate form? Assume that the volumes are additive.

a) i) $Cu(OH_2)_{(s)} \rightarrow Cu^{+2}_{(aq)} + 2OH^-_{(aq)}$ (must have states)

ii) $\left(\frac{1.72\times10^{-6}\,g\,Cu(OH)_2}{100\,mL}\right)\left(\frac{1000\,mL}{1\,L}\right)\left(\frac{1\,mole\,Cu(OH)_2}{97.57\,g\,Cu(OH)_2}\right) = 1.76\times10^{-7}\,M$

	$Cu(OH_2)$	$\rightarrow$	Cu^{+2}	+	$2OH^-$
I	1.76×10^{-7} M		0		0
C			+X		+2X
E			1.76×10^{-7}		

$Cu(OH)_2 : Cu^+$
1:1

$2(1.76\times10^{-7}) = 3.52\times10^{-7} = [OH^-]$

$Ksp = [OH^-]^2[Cu^{+2}]$
$= (3.52\times10^{-7})^2(1.76\times10^{-7})$
$Ksp = 2.18\times10^{-20}$

B) $Zn^{+2} + 2OH^- \rightleftharpoons Zn(OH)_{2\,(s)}$

.00500 moles .0150 moles

Zn^{+2} $\left(\frac{.100\,Zn^{+}\,mol}{1\,L}\right)\left(\frac{.0500\,L}{1}\right) = .00500$ mols

OH^- $\left(\frac{.300\,mole}{1\,L}\right)\left(\frac{.0500\,L}{1}\right) = .0150$ mols

$Q = [Zn][OH^-]^2$
$= (.00500)(.0150)^2$
$Q = 1.13\times10^{-6}$

$Q > K_{sp} = 7.7\times10^{-17}$
∴ Precipitate will form