

(A)	2 NO(g)	+ 2 H <sub>2</sub> (g)	⇌	N <sub>2</sub> (g)	+ 2 H <sub>2</sub> O(g)	at <u>300K</u>
Initial	.1000 mole	.0500 moles		0	.1000 moles	
Change	-.0379	-.0379		+.01895	+.0379	
Equilibrium (given)	.0621 moles remain	.0121 moles		.01895 moles	.1379 moles	

from this you can figure out how many moles of NO reacted..

.1000 - .0621 = 0.0379 moles NO reacted.

The same amount of H<sub>2</sub> reacts.. The same amt of H<sub>2</sub>O will form. but only half this much N<sub>2</sub> will form, by 1:2 ratio

- 1) .0621 moles NO remain (given) (at eqm)
- .0121 moles H<sub>2</sub>
- .01895 moles N<sub>2</sub>
- .1379 moles H<sub>2</sub>O

2) since volume is 1 Liter, molarities will be same as moles.

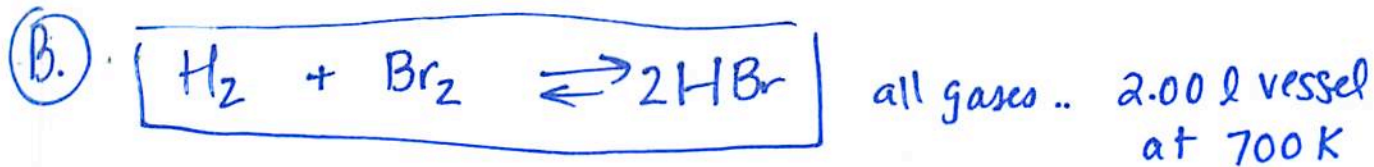
3.) 
$$K_c = \frac{[N_2][H_2O]^2}{[NO]^2[H_2]^2} = \frac{(0.01895)(.1379)^2}{(.0621)^2(.0121)^2} = 638.2397$$

$K_c = 638$

4)  $K_p = K_c (RT)^{\Delta n}$        $\Delta n = 3 \text{ moles gas} - 4 \text{ moles gas} = -1 \text{ moles gas}$

~~K<sub>p</sub>~~  $K_p = (638.2397) [(0.0821)(300K)]^{-1}$

$K_p = 25.9$



(B)

starts with 1.374 g  $\text{H}_2$  70.31 g  $\text{Br}_2$  .. in 2.00 l vessel.

Initial molarities:

$$\frac{\frac{1.374 \text{ g H}_2}{2.0158 \text{ g/mole}}}{2.00 \text{ l}} = 0.340808 \text{ M H}_2$$

$$\frac{\frac{70.31 \text{ g Br}_2}{159.808 \text{ g/mole}}}{2.00 \text{ l}} = 0.21998 \text{ M Br}_2$$

at equilibrium, there are 0.566 g  $\text{H}_2$ ..

$$\frac{.566 \text{ g} / 2.0158 \text{ g/mole}}{2.00 \text{ l}} = 0.1403909 \text{ M H}_2 \text{ remains.}$$

$.340808 - .1403909 = 0.200417 \text{ M H}_2$  changed .. was reacted.



I	.340808	.21998	0	) Molarity units
Δ	<u>-.200417</u>	<u>-.200417</u>	<u>+2(.200417)</u>	
E	.1403909	.019563	.40083	

← answers to (a)

$$K_c = \frac{[\text{HBr}]^2}{[\text{H}_2][\text{Br}_2]} = \frac{(.40083)^2}{(.1403909)(.019563)} = 58.4987 \rightarrow \boxed{K_c = 58.5}$$

$$K_p = K_c (RT)^{\Delta n} \quad \dots \quad \Delta n = 0 \quad \text{so} \quad \boxed{K_p = K_c = 58.5}$$



I  $.10 M$   $.10 M$   $0$

$\frac{-x}{.10 - x}$   $\frac{-x}{.10 - x}$   $\frac{+2x}{2x}$

E  $.10 - x$   $.10 - x$   $2x$

(C)

got  $.10 M$  by dividing  $.20$  moles of  $I_2$  (or  $Br_2$ ) by  $2 l$  volume.

$$K_c = \frac{[IBr]^2}{[I_2][Br_2]} \quad 280 = \frac{(2x)^2}{(.10 - x)(.10 - x)}$$

$$280 = \frac{4x^2}{(.10 - x)^2} \quad \text{.. be lazy, square root each side}$$

$$\frac{2x}{.10 - x} = \sqrt{280} = 16.733$$

( $.10 - x$  must be positive since started with only reactants)

$$2x = 16.733(.10 - x) = 1.6733 - 16.733x$$

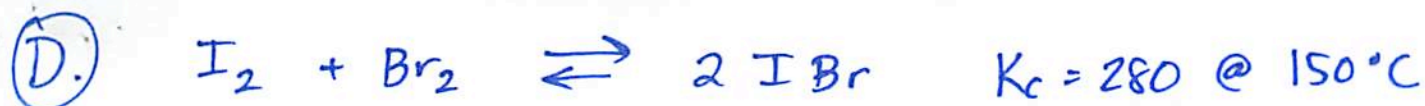
$$18.733x = 1.6733$$

$$x = 0.08932 M$$

$$[IBr] = 2x = 2(.08932) = 0.1786 \rightarrow \boxed{0.18 M} = [IBr]$$

$$[I_2] = [Br_2] = 0.10 - x = 0.10 - .08932 = 0.0107 \rightarrow$$

$$[Br_2] = [I_2] = \boxed{0.01 M}$$



I	.100 M	.150 M	0
Δ	<u>-x</u>	<u>-x</u>	<u>+2x</u>
F	.100-x	.150-x	2x

(D)

↑  
 $.10 M = \frac{.200 \text{ moles } I_2}{2.00 L}$        $.15 M = \frac{.30 \text{ moles } Br_2}{2.0 L}$

$$\frac{[IBr]^2}{[I_2][Br_2]} = 280$$

$$\frac{(2x)^2}{(.10-x)(.15-x)} = 280$$

$$4x^2 = 280 (.015 - .25x + x^2)$$

$$4x^2 = 4.2 - 70x + 280x^2$$

$$276x^2 - 70x + 4.2 = 0$$

$$x = \frac{70 \pm \sqrt{(-70)^2 - 4(276)(4.2)}}{2(276)} = \frac{70 \pm 16.223}{552}$$

$$x = 0.1562 \quad \text{OR} \quad \underline{\underline{0.09742}}$$

↑

x can't be this cause we only started w/ 0.10 M  $I_2$

$$[I_2] = .100 - x = .100 - .09742 = 0.00258 \rightarrow [I_2] = .003 M$$

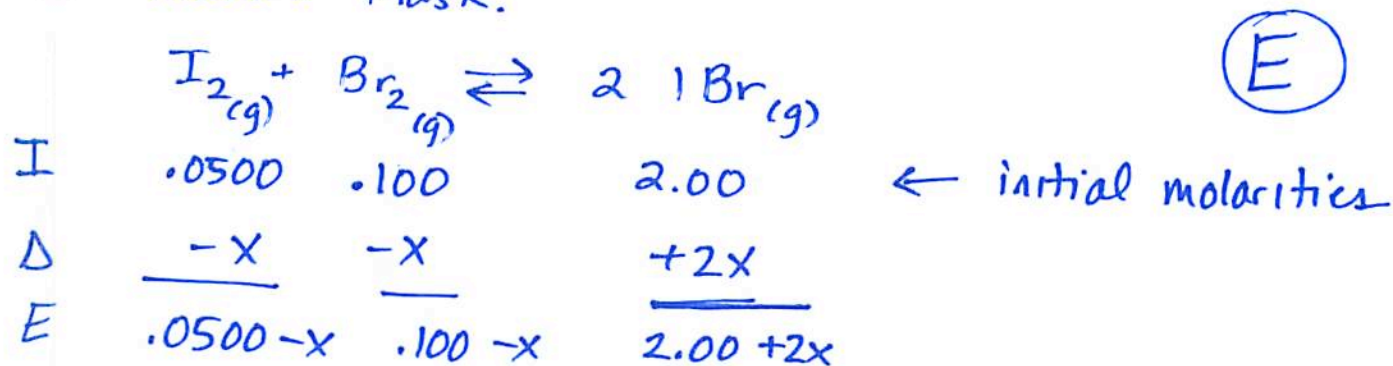
$$[Br_2] = .150 - x = .0526 \rightarrow [Br_2] = 0.053 M$$

$$[IBr] = 2x = 0.195 M = [IBr]$$

check:  $\frac{(.195)^2}{.00258 \cdot .0526} = 279.7 \checkmark$



start with .100 moles  $I_2$ , .200 moles  $Br_2$ , 4.00 moles  $IBr$  in 2.000 l flask.



$$K_c = \frac{[IBr]^2}{[I_2][Br_2]} = 280 = \frac{(2.00 + 2x)^2}{(.0500 - x)(.100 - x)}$$

$$280 = \frac{(4.00 + 8.00x + 4x^2)}{.00500 - .150x + x^2}$$

$$.60(.0500 - .150x + x^2) = 4.00 + 8.00x + 4x^2$$

$$1.4 - 42x + 280x^2 = 4.00 + 8.00x + 4x^2$$

$$276x^2 - 50x - 2.6 = 0$$

$$x = \frac{50 \pm \sqrt{(-50)^2 - 4(276)(-2.6)}}{2(276)} = \frac{50 \pm 73.283}{552}$$

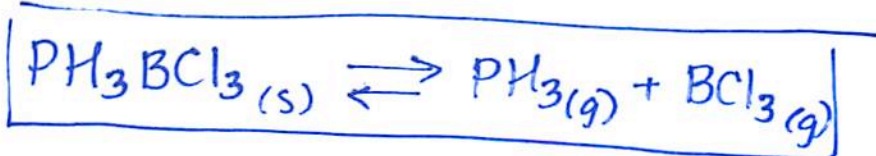
$$x = 0.2233 \quad \text{or} \quad -0.04218$$

↑  
this is too large.. cant have negative amount of reactant left.

~~x = 0.2233~~  $x = -.04218$  .. negative x means the reaction shifted left.. makes sense since we had a lot of product.

$[IBr] = 2.00 + 2x = 2.00 + 2(-.04218) = 1.92 \text{ M } IBr$
$[I_2] = .0500 - x = .0500 - (-.04218) = .09218 \rightarrow .092 \text{ M } I_2$
$[Br_2] = .100 - x = .100 - (-.04218) = 0.14218 \rightarrow 0.142 \text{ M } Br_2$

(F) based on 15.39)



(F)

given:  $K_p = 5.42 \times 10^{-2}$  at  $80^\circ\text{C}$

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

$$\Delta n = \frac{2 \text{ moles product gas} - 0 \text{ moles react. gas}}{\Delta n = 2}$$

$$(5.42 \times 10^{-2}) = K_c [(0.0821)(353)]^2$$

$$K_c = 6.453 \times 10^{-5}$$

$$\rightarrow \boxed{K_c = 6.45 \times 10^{-5}}$$

b) calculate eqm partial pressures: if you start with just solid  $\text{PH}_3\text{BCl}_3$

$$K_p = P_{\text{PH}_3} \cdot P_{\text{BCl}_3} \quad 5.42 \times 10^{-2} = x^2$$

$$x = 0.2328$$

$$\boxed{P_{\text{PH}_3} = P_{\text{BCl}_3} = 0.233 \text{ atm}}$$

↑ pressures of  $\text{PH}_3, \text{BCl}_3$  must be equal by stoichiometry if we just had solid at start.

c) calc. eqm molarities

$K_c = [\text{PH}_3][\text{BCl}_3]$  -- again, molarities of products are equal if you just start w/ solid in the flask.

$$6.45(3) \times 10^{-5} = x^2$$

$$x = [\text{PH}_3] = [\text{BCl}_3] = \boxed{0.00803 \text{ M}}$$

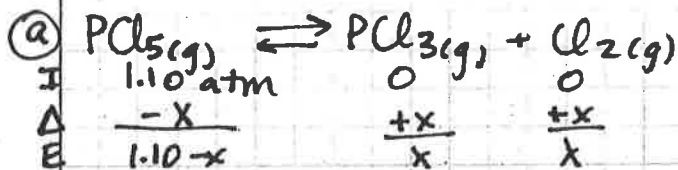
d) flask volume given: 0.500 l

$$\left(0.00803 \frac{\text{mole}}{\text{L}}\right)(0.500 \text{ l}) = \boxed{0.00402 \text{ moles PH}_3 \text{ and } 0.00402 \text{ moles BCl}_3 \text{ at eqm.}}$$

e) how many grams solid needed to establish an eqm: need 0.00402 moles solid to produce 0.00402 moles gas. each

$$\left(0.00402 \text{ moles}\right) \left(\frac{151.167 \text{ g PH}_3\text{BCl}_3}{1 \text{ mole}}\right) = \boxed{0.608 \text{ g needed}}$$

# Problem 6



given: Initial  $P_{\text{PCl}_5} = 1.10 \text{ atm}$   
 EQM total gas pressure = 1.87 atm  
 (250°C)

$$P_{\text{TOTAL}} @ \text{EQM} = P_{\text{PCl}_5} + P_{\text{PCl}_3} + P_{\text{Cl}_2}$$

$$1.87 \text{ atm} = 1.10 - x + x + x$$

$$1.87 \text{ atm} = 1.10 + x$$

$$x = 0.77 \text{ atm}$$

So  $P_{\text{PCl}_5} = 1.10 - 0.77 = 0.33 \text{ atm} @ \text{EQM}$

$P_{\text{PCl}_3} = P_{\text{Cl}_2} = 0.77 \text{ atm} @ \text{EQM}$

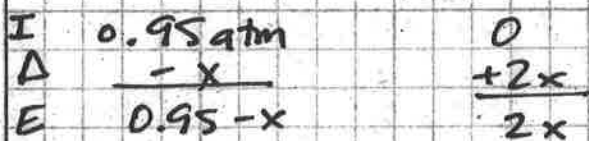
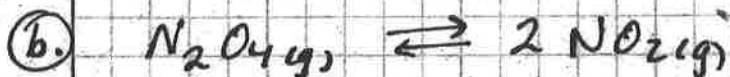
$$K_p = \frac{P_{\text{PCl}_3} \cdot P_{\text{Cl}_2}}{P_{\text{PCl}_5}} = \frac{(0.77)^2}{(0.33)} = 1.796 \rightarrow \boxed{K_p = 1.8}$$

$$K_p = K_c (RT)^{\Delta n} = K_c (RT)^1$$

$$1.796 = K_c (.0821 \cdot 523 \text{ K})$$

$$K_c = 0.0418$$

$$\boxed{K_c = 0.042}$$



given:  $P_{\text{N}_2\text{O}_4} \text{ initial} = 0.95 \text{ atm}$

$P_{\text{TOTAL}} @ \text{EQM} = 1.19 \text{ atm}$

(25°C)

$$P_{\text{TOTAL}} = 0.95 - x + 2x = 1.19 \text{ atm}$$

$$x = 0.24 \text{ atm}$$

$P_{\text{N}_2\text{O}_4} @ \text{EQM} = 0.95 - 0.24 = 0.71 \text{ atm}$

$P_{\text{NO}_2} @ \text{EQM} = 2(0.24) = 0.48 \text{ atm}$

$$K_p = \frac{(P_{\text{NO}_2})^2}{(P_{\text{N}_2\text{O}_4})} = \frac{(0.48)^2}{(0.71)} = 0.3245$$

So  $\boxed{K_p = 0.32}$

(contd on next page)

# Problem 6, Contd)



↑  
solid placed into  
an empty flask

given: total EQM pressure is 0.44 atm @ 55°C

If only solid is placed in the flask, as the solid reacts to form  $\text{PH}_3$  and  $\text{BCl}_3$  gases, it will produce equal moles (and therefore equal pressures) of each gas by stoichiometry.

so  $P_{\text{PH}_3} = P_{\text{BCl}_3} = x$

Total Pressure @ EQM =  $P_{\text{PH}_3} + P_{\text{BCl}_3} = x + x = 2x$

$2x = 0.44 \text{ atm}$

$x = 0.22 \text{ atm}$

so  $K_p = (P_{\text{PH}_3})(P_{\text{BCl}_3})$

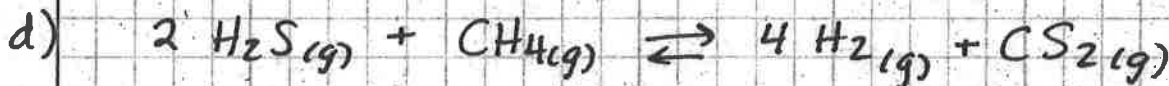
$= (0.22)(0.22) = 0.0484$

$K_p = 0.048$

$K_p = K_c (RT)^{\Delta n}$      $\Delta n = 2 - 0 = 2$

$0.048 = K_c (.0821 \cdot 328)^2$

$K_c = 6.7 \times 10^{-5}$



I	0.600 atm	0.400 atm	0	0
Δ	-2x	-x	+4x	+x
E	.600 - 2x	.400 - x	4x	x

given:  $P_{\text{TOTAL}} = 1.084 \text{ atm}$  (@ 973 K) at equilibrium

$P_{\text{TOTAL}} = (0.600 - 2x) + (0.400 - x) + 4x + x = 1.084 \text{ atm}$

$1.000 + 2x = 1.084$

$x = 0.042 \text{ atm}$

so  $P_{\text{H}_2\text{S}} = .600 - 2(0.042) = 0.516 \text{ atm H}_2\text{S}$

$P_{\text{CH}_4} = .400 - (.042) = 0.358 \text{ atm CH}_4$

$P_{\text{H}_2} = 4(.042) = 0.168 \text{ atm H}_2$

$P_{\text{CS}_2} = 0.042 \text{ atm CS}_2$

$K_p = 0.00035$

$K_p = \frac{(P_{\text{H}_2})^4 (P_{\text{CS}_2})}{(P_{\text{H}_2\text{S}})^2 (P_{\text{CH}_4})} = \frac{(0.168)^4 (0.042)}{(0.516)^2 (0.358)} = 0.000350997$

$K_p = K_c (RT)^{\Delta n}$      $\Delta n = 5 - 3 = 2$

$0.00035 = K_c (.0821 \cdot 973)^2$   
 $K_c = 5.5 \times 10^{-8}$