Problem Solving (25 marks)

Name.
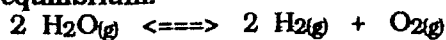
1. Consider the following equilibrium:
$$2 H_2O_{(g)} \Longleftrightarrow 2 H_{2(g)} + O_{2(g)}$$
Identify two ways to increase the rate of the forward reaction: (2 marks)

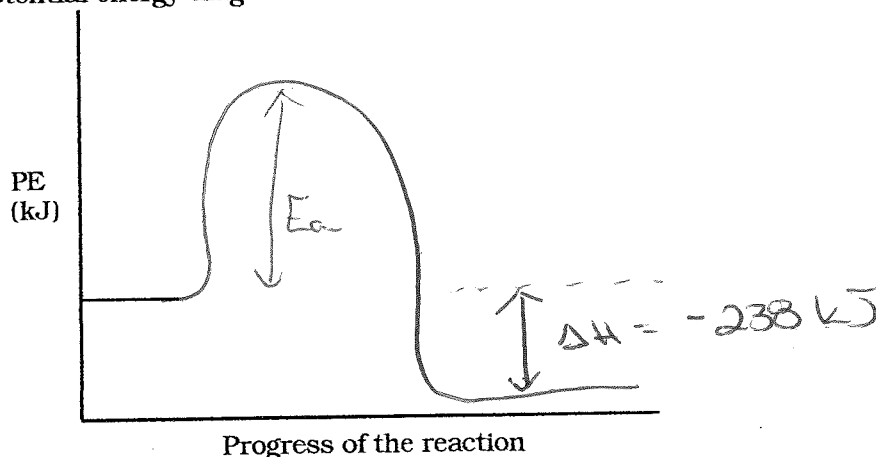i) _Add a catalyst_

ii) _↓P or ↑V_

↑$[H_2O]$ OR ↑$[H_2]$ OR ↑$[O_2]$

2. Identify four characteristics of a chemical equilibrium. (2 marks)

i) closed system

ii) constant [ ]

iii) constant Temp

iv) constant P/V

fwd = rev rxn rate

3. Consider the following equilibrium:
$$CS_{2(g)} + 3 Cl_{2(g)} \Longleftrightarrow CCl_{4(g)} + S_2Cl_{2(g)} \qquad \Delta H = -238 \text{ kJ}$$
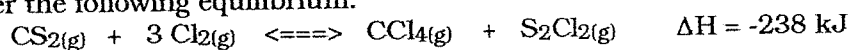
a. Sketch a potential energy diagram for the reaction above and label ΔH. (2 marks)

PE
(kJ)

Ea

ΔH = -238 kJ

Progress of the reaction

b. Some CS_2 is added and equilibrium is then reestablished. State the direction of the equilibrium shift and the resulting change in $[Cl_2]$. (1 mark)

- shift right
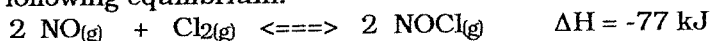
- ↓$[Cl_2]$

c. The temperature is decreased and equilibrium is then reestablished. What will the effect be on the value of Keq? (1 mark)

K_{eq} ↑

4. Consider the following equilibrium:

$$2 \ NO_{(g)} \ + \ Cl_{2(g)} \ \Longleftrightarrow \ 2 \ NOCl_{(g)} \qquad \Delta H = -77 \ kJ$$

What happens to the amount of Cl_2 when the following changes are imposed? Explain using Le Chatlier's principle.
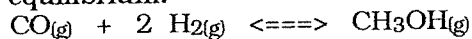
a. Removing $NO_{(g)}$ (1 mark)

$\uparrow [Cl_2]$ rxn shift $\leftarrow$

b. Decreasing the temperature (1 mark)

$\downarrow [Cl_2]$ rxn shift $\rightarrow$

5. Consider the following equilibrium:

$$CO_{(g)} \ + \ 2 \ H_{2(g)} \ \Longleftrightarrow \ CH_3OH_{(g)}$$

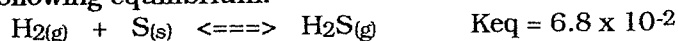Explain, using Le Chatlier's principle, how the following changes will affect the number of moles of CH_3OH present at equilibrium.

a. Adding a catalyst. (1 mark)

no change

b. Decreasing the volume of the system (1 mark)

shift right $\uparrow [CH_3OH]$

6. Consider the following equilibrium:

$$H_{2(g)} \ + \ S_{(s)} \ \Longleftrightarrow \ H_2S_{(g)} \qquad Keq = 6.8 \ x \ 10^{-2}$$

A 1.0 L container is initially filled with 0.050 mol H_2 and 0.050 mol S. The container is heated to 90°C and equilibrium is established. What is the equilibrium $[H_2S]$? (3 marks)

ICE table:

I: .05 | 0
C: -x | x
E: .05-x | x

$Keq = \dfrac{[H_2S]}{[H_2]}$

$$Keq = 6.8 \times 10^{-2} = \frac{x}{.05-x}$$

$0.0034 - 6.8 \times 10^{-2} = x$

$.0034 = 1.068 x$

$x = 0.00318$

$[H_2S] = 0.0030 \ M$

7. Consider the following equilibrium:

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2\ HI_{(g)} \qquad K_{eq} = 64$$
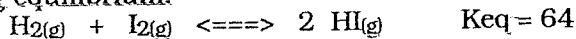
Equal moles of H_2 and I_2 are placed in a 1.00 L container. At equilibrium, the $[HI]$ = 0.160 mol/L. Calculate the initial $[H_2]$. (3 marks)

(1)

	I	X	X	0
C		-.08	-.08	.160
E		x-.08	x-.08	.160

(2) $K_{eq} = \dfrac{[HI]^2}{[H_2][I_2]}$

$64 = \dfrac{(.160)^2}{(x-.08)^2}$

$\boxed{[H_2] = 0.10\ M}$ (1)

$8 = \dfrac{.160}{x-.08}$

$8x - .64 = .160$

$8x = .8$

$x = 0.1$ ✓

8. At high temperature, 0.500 mol HBr was placed in a 1.00 L container where it decomposed to give the equilibrium:

$$2\ HBr_{(g)} \rightleftharpoons H_{2(g)} + Br_{2(g)}$$
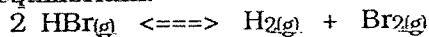
At equilibrium, the $[Br_2]$ is 0.0855 mol/L. What is the value of the equilibrium constant? (3 marks)

	I	.0500	0	0
C		-.171	.0855	.0855
E		.329	.0855	.0855

$K_{eq} = \dfrac{[H_2][Br_2]}{[HBr]^2}$

$= \dfrac{(0.0855)^2}{(.329)^2}$

$K_{eq} = \dfrac{0.00731}{0.108241} = 0.0675$ ✓

9. Consider the following:
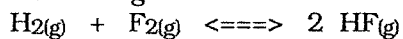
$$H_{2(g)} + F_{2(g)} \iff 2\ HF_{(g)} \qquad K_{eq} = 1.00 \times 10^2$$

A 1.00 L flask is initially filled with 2.00 mol H_2 and 2.00 mol F_2. Calculate the $[H_2]$ at equilibrium. (4 marks)

①

	H	F	
I	2	2	0
C	$-x$	$-x$	$2x$
E	$2-x$	$2-x$	$2x$

①

$$K_{eq} = \frac{[HF]^2}{[H_2][F_2]}$$

$$1.00 \times 10^2 = \frac{(2x)^2}{(2-x)^2}$$

$$10 = \frac{2x}{2-x}$$

$$20 - 10x = 2x$$
$$20 = 12x$$
$$x = 1.67 \qquad ①$$

$$[H_2] = 2-x$$
$$= 2-1.67$$
$$[H_2] = .33\emptyset M \qquad ①$$

Chemistry 12
Equilibrium
version 1

Name:_____

Block:_____

Part 1: Multiple Choice

Outcome 1	Outcome 2	Outcome 3	Outcome 4	Review
1. D	5. B	9. B	17. D	25. C
2. A	6. D	10. A	18. B	26. A
3. B	7. D	11. A	19. D	27. B
4. A	8. D	12. B	20. A	28. B
		13. B	21. C	
		14. D	22. A	
		15. D	23. B	
		16. B	24. C	