Year 12 Chemistry **Topic Test #1 (Equilibrium) - 2011**

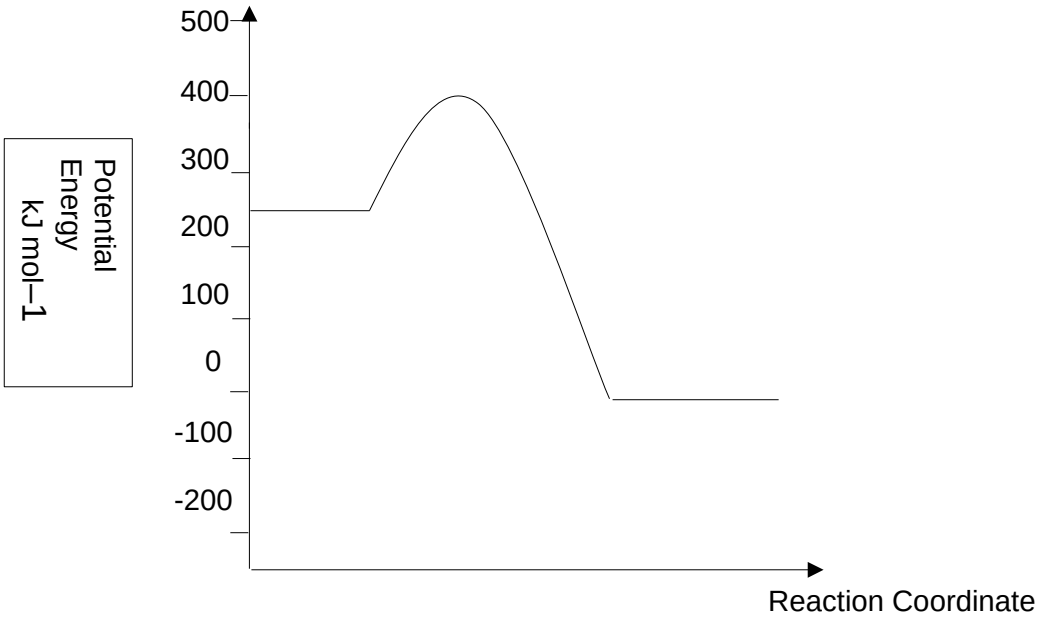
Name:_____ Mark = _____ / 43

Part 1: Multiple Choice Section **10 marks**

The next two questions are concerned with the reaction:

$$CO_{(g)} + NO_{2(g)} \rightleftarrows CO_{2(g)} + NO_{(g)}$$

The potential energy diagram for the above reaction is shown below.



1. For the reverse reaction, the heat of reaction (ΔH) and the activation energy (E_a) are:

   A. $\Delta H = +250$ $E_a = 150$

   B. $\Delta H = -250$ $E_a = 150$

   C. $\Delta H = +250$ $E_a = 400$

   D. $\Delta H = -400$ $E_a = 250$

2. At equilibrium, which one of the following statements is **true**?

   A. The activations energies of the forward and reverse reactions are equal.

   B. The rates of the forward and reverse reactions are zero.

   C. The sum of the concentrations of the reactants equal the sum of concentrations of the products.

   D. The rate of production of CO equals the rate of production of CO_2.

3. An experiment is carried out to investigate the effect of temperature change on the reaction represented by the equation:

$$N_2O_{4(g)} \rightleftarrows 2\ NO_{2(g)} \qquad \Delta H = +54.8\ kJ\ mol^{-1}$$

What will result if the temperature increases?

A. The value of the equilibrium constant will remain the same, but equilibrium will be reached more quickly.

B. The value of the equilibrium constant will remain the same but equilibrium will be reached more slowly.

C. The value of the equilibrium constant will increase.

D. The value of the equilibrium constant will decrease.

4. Given the reaction:

$$A_{2(g)} + B_{2(g)} \rightleftarrows 2\ AB_{(g)} + \text{heat}$$

An increase in the concentration of $A_{2(g)}$ will:

A. decrease the rate of production of $AB_{(g)}$.

B. decrease the frequency of collisions between $A_{2(g)}$ and $B_{2(g)}$.

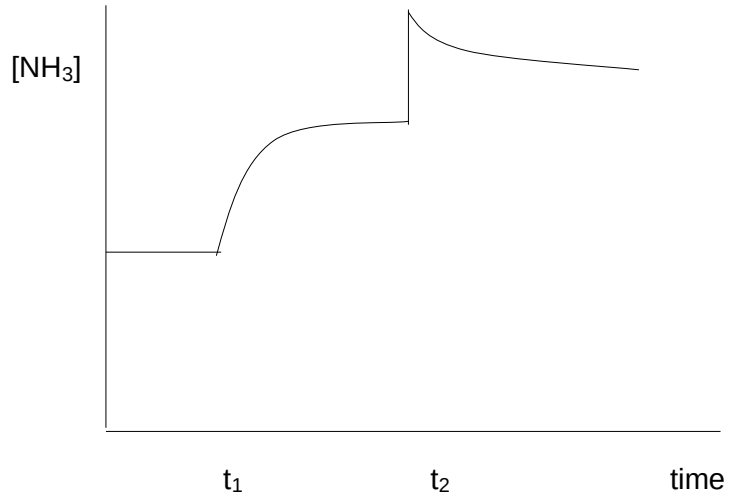
C. increase the rate of production of $B_{2(g)}$.

D. increase the frequency of collisions between $A_{2(g)}$ and $B_{2(g)}$.

5. Consider the equilibrium system:

$$N_{2(g)} + 3\ H_{2(g)} \rightleftarrows 2\ NH_{3(g)} \qquad \Delta H = -92\ kJ\ mol^{-1}$$

Which of the following best describes changes made to the system would result in the changes shown at t_1 and t_2 respectively in the diagram below?



A. Temperature initially increased following by addition of a catalyst.

B. Temperature initially increased following by addition of extra ammonia gas.

C. Temperature initially decreased following by addition of extra ammonia gas.

D. Temperature initially decreased following by an increase in reaction volume.

6. The value of the equilibrium constant for the reaction:

$$H_{2(g)} + CO_{2(g)} \rightleftarrows H_2O_{(g)} + CO_{(g)} \qquad \Delta H = +42 \text{ kJ mol}^{-1}$$

is 1.6 at 990°C. If equimolar amounts of H_2, CO_2, H_2O and CO which were initially at 990°C were mixed in a thermally insulated vessel, the temperature of the gases would:

A. increase and the mass of H_2 would increase.

B. increase and the mass of H_2 would decrease.

C. decrease and the mass of H_2 would increase.

D. decrease and the mass of H_2 would decrease.

7. For the reaction: $PC\ell_{5(g)} \rightleftarrows PC\ell_{3(g)} + C\ell_{2(g)}$

The initial rate of the forward reaction at constant temperature is **not** favoured by:

A. increasing the temperature.

B. introducing an inert gas at constant pressure.

C. introducing $PC\ell_5$ at constant volume.

D. decreasing volume of the container.

8. Raising the temperature of a reacting system increases the rate of the reaction but does **not** increase the:

A. number of collisions.

B. fraction of reacting particles which possess energies greater than the activation energy.

C. the average velocity of the reacting particles.

D. activation energy.

9. Consider the following equilibrium system:

$$CO_{(g)} + C\ell_{2(g)} \rightleftarrows COC\ell_{2(g)}$$

At a certain temperature, after equilibrium has been reached, the concentrations of the reactants and products were found to be the following:

$[CO] = 0.30 \text{ mol L}^{-1}$ $[C\ell_2] = 0.20 \text{ mol L}^{-1}$ $[COC\ell_2] = 0.80 \text{ mol L}^{-1}$

The numerical value of the equilibrium constant, K, for the system at this temperature is:

A. 13.3

B. 0.53

C. 0.75

D. 53

10. A change is made on a system at equilibrium and it is observed that the equilibrium position moves to the right (products side).

Which of the following is consistent with this observation?

A. $2\ C\ell_{2(g)} + 7\ O_{2(g)} \rightleftarrows 2\ C\ell_2O_{7(g)}$

The pressure is increased by adding neon gas to the vessel.

B. $H_{2(g)} + I_{2(g)} \rightleftarrows 2\ HI_{(g)}$

The pressure is decreased by removal of some of the $HI_{(g)}$

C. $2\ H_{2(g)} + O_{2(g)} \rightleftarrows 2\ H_2O_{(g)} \quad \Delta H = -484\ kJ$

The temperature is increased.

D. $I_{2(s)} \rightleftarrows I_{2(aq)}$

More solid iodine is added.

Part 2: Short Answer Section **33 marks**

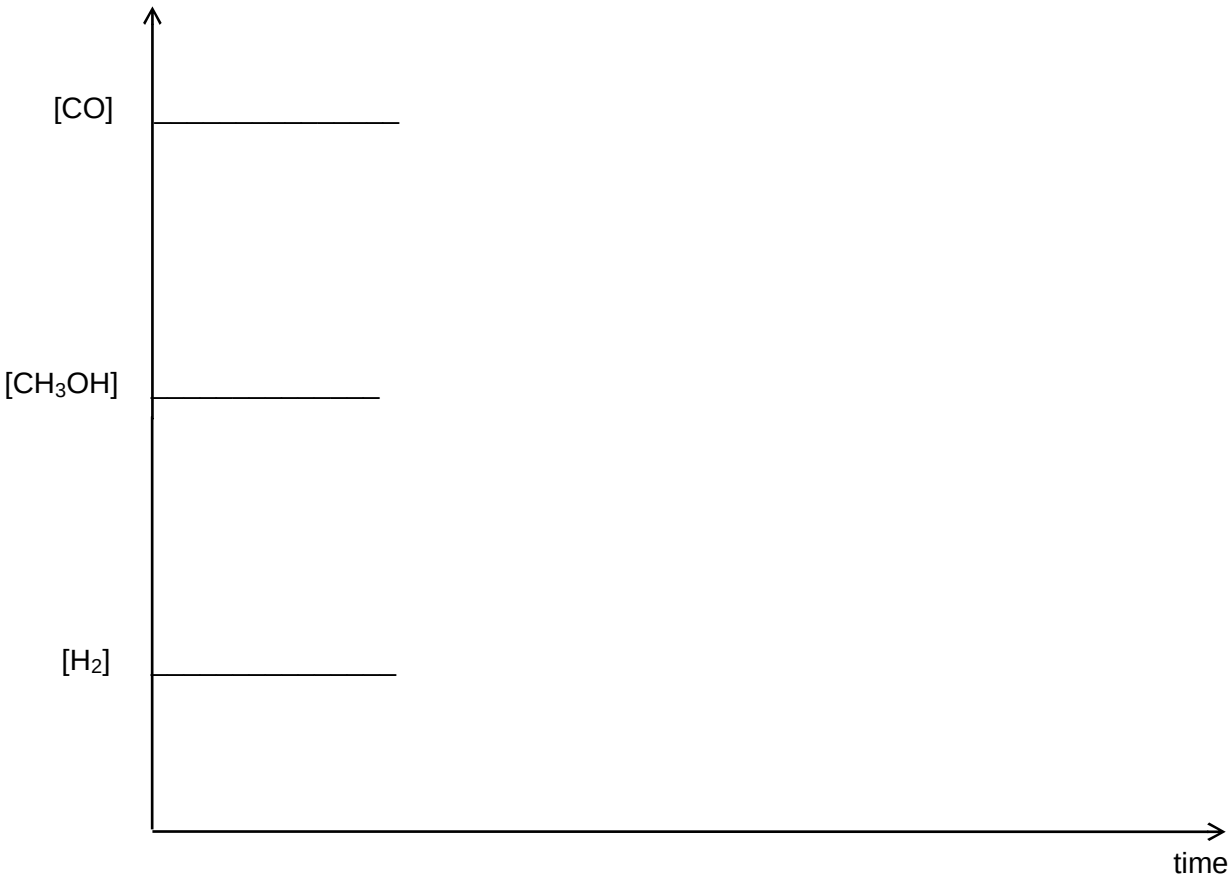
1. Consider an equilibrium mixture due to the reaction:

$$CO_{(g)} + 2\,H_{2(g)} \rightleftarrows CH_3OH_{(g)} \qquad \Delta H = -91 \text{ kJ mol}^{-1}$$

Draw (i) rate-time and (ii) concentration-time sketches to show the return to equilibrium when there is an increase in the volume of the cylinder containing the equilibrium mixture.

[———— forward reaction ---------- reverse reaction]

concentration



[3 + 3 = 6 marks]

2. Gaseous ethanal, CH_3CHO can decompose to form methane gas, CH_4, and carbon monoxide gas, CO. The activation energy for this process is 191 kJ for each mole of ethanal decomposed. The reaction releases 10 kJ of energy for each mole of carbon atoms involved in the reaction.

(a) Write an equation for the decomposition of ethanal including state symbols.

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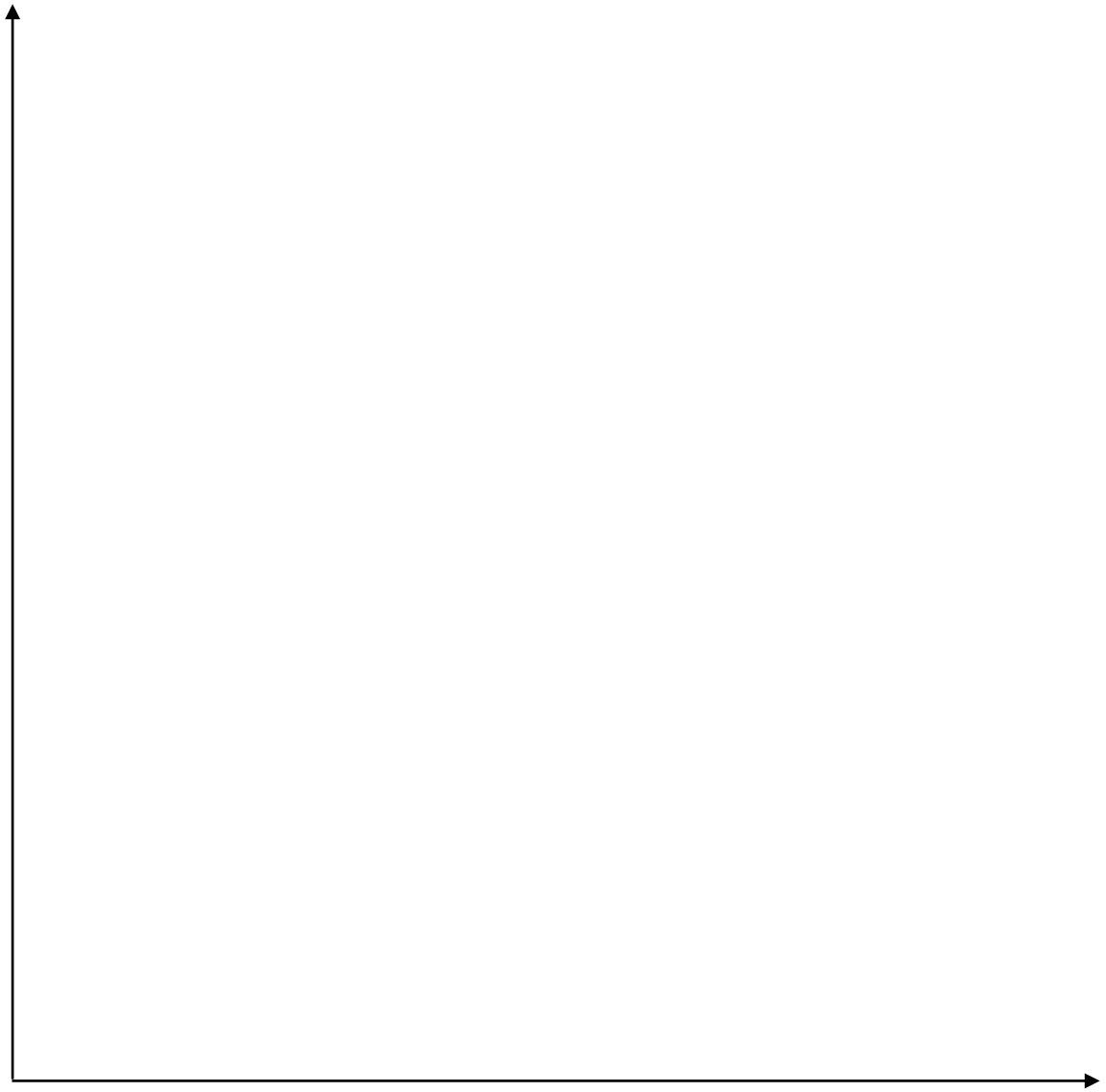
(b) Give the value, including the sign, of the heat of reaction for the reaction you have represented in part (a), above.

_____

(c) Sketch an energy profile diagram for the reaction. Your sketch should indicate intervals labelled as "ΔH" and "activation energy". Show the magnitude of these quantities. Label the axes and include the terms "activated complex" (or transition state") and "reaction coordinate" in the appropriate places in your diagram.



[1 + 1 + 4 = 6 marks]

3. Consider the following equilibrium:

$$Cr_2O_7^{2-}{}_{(aq)} + 2\ OH^-{}_{(aq)} \rightleftarrows 2\ CrO_4^{2-}{}_{(aq)} + H_2O_{(l)} \qquad \Delta H = -97\ kJ\ mol^{-1}$$

Two test tubes were set up, each containing some of the equilibrium mixture. A different change was imposed on each test tube.

Predict what would be observed and give reasons why.

Imposed change	Observations	Explanation using Le Chatelier's Principle
Temperature is decreased		
A little concentrated sulfuric acid is added		

[4 + 4 = 8 marks]

4. The following equilibrium has a value for K of 0.042 at 25°C.

$$PC\ell_{5(g)} \rightleftarrows PC\ell_{3(g)} + C\ell_{2(g)}$$

If 0.20 mol $PC\ell_3$, 0.20 mol $C\ell_2$ and 0.50 mol $PC\ell_5$ were mixed in a 1.0 L container at 25°C, the reaction will shift left in order to establish equilibrium. Explain why.

[3 marks]

5. Tooth decay is the result of the dissolving of tooth enamel, $Ca_5(PO_4)_3OH_{(s)}$.

In the mouth the following equilibrium is established:

$$Ca_5(PO_4)_3OH_{(s)} \rightleftarrows 5\ Ca^{2+}_{(aq)} + 3\ PO_4^{3-}{}_{(aq)} + OH^-_{(aq)}$$

When sugar ferments on teeth it produces acidic compounds. Explain, in terms of the above equilibrium, the effect of these compounds on tooth enamel.

[3 marks]

6. Consider the reaction:

$H_{2(g)} + C\ell_{2(g)} \rightleftarrows 2\,HC\ell_{(g)}$ with $K = 1.7 \times 10^4$ at 450°C

(a) Determine K of the following at 450°C:

$2\,HC\ell_{(g)} \rightleftarrows H_{2(g)} + C\ell_{2(g)}$

[2 marks]

(b) If the pressure of the system $H_{2(g)} + C\ell_{2(g)} \rightleftarrows 2\,HC\ell_{(g)}$ was increased by decreasing its volume at 450°C, then:

(i) in which direction would the system shift? _____

(ii) the value of K would _____

[2 marks]

(c) At 678°C, $K = 1.34 \times 10^5$ for $H_{2(g)} + C\ell_{2(g)} \rightleftarrows 2\,HC\ell_{(g)}$.

Is the forward reaction for this system exothermic or endothermic? Explain.

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[3 marks]

End of Test