Year 12 Chemistry   **Topic Test # 1 (Equilibrium) - 2012**
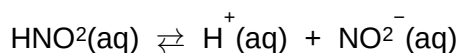
Name: _____   Mark = _____ / 39

**Part 1: Multiple Choice Section**   **7 marks**
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1. HNO_2, nitrous acid behaves in water as a weak acid

$$HNO^2(aq) \rightleftharpoons H^+(aq) + NO^{2-}(aq)$$

A strong acid, sulfuric acid is added to a solution of nitrous acid. After equilibrium has been re-established:

A.   the pH will have increased

B. $[NO^{2-}]$ increases

C.   the value of the fraction $[H^+][NO^{2-}]$ will not have changed at constant temperature

$$[HNO_2^-]$$

D. $[H^+]$ will decrease since equilibrium shifts to the left

2.   In an experiment, 2 g of Mg shavings dissolve in 500 mL of 2 mol L^{-1} HCℓ with the production of considerable quantities of heat. Which one of the following actions will NOT increase the initial rate of production of hydrogen ?

A.   Using 10 g of the original Mg shavings instead of 2 g

B.   Heating the reaction mixture

C.   Using 600 mL of 2 mol L^{-1} HCℓ instead of 500 mL

D.   Stirring the reaction vessel

3.   If 2 g of sodium dichromate is dissolved in 100 mL of distilled water, which one of the following actions will increase the concentration of chromate ion in the mixture ?

The system is $2 CrO_4^{2-}(aq) + 2 H^+(aq) \rightleftharpoons Cr^2O^{7^{2-}}(aq) + 2 H^2O(l)$
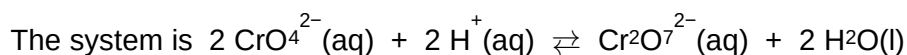
A.   adding dilute sulfuric acid to the mixture

B.   adding 1 mL of dilute sodium hydroxide solution to the mixture

C.   adding 100 mL of distilled water to the mixture

D.   adding 2 mL of distilled water to the mixture

4.   Consider the following equilibrium system:

   $N_2(g) + 3 H_2(g) \rightleftarrows 2 NH_3(g) + 92 kJ$
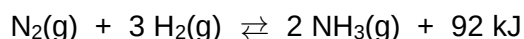
   The system was initially at equilibrium at a total pressure higher than local atmospheric pressure but a leak was found in the reaction flask. The leak was then fixed and equilibrium is re-established. This has caused:

   A.   No change in the forward reaction rate but yield of NH_3 is decreased.

   B.   A decrease in the forward reaction rate and yield of NH_3 is decreased.

   C.   A decrease in the forward reaction rate but yield of NH_3 is increased.

   D.   An increase in the forward reaction rate but yield of NH_3 is unchanged.

The next two questions, 5 and 6, are concerned with the reaction

   $CO(g) + NO_2(g) \rightleftarrows CO_2(g) + NO(g)$
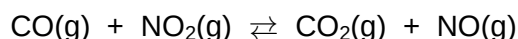
The potential energy diagram for the reaction is shown below:

Reaction Coordinate
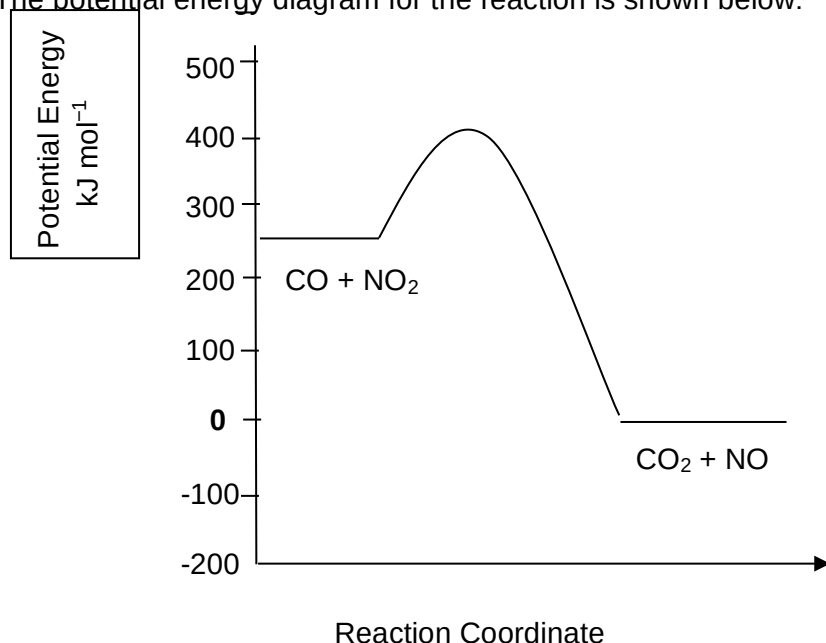
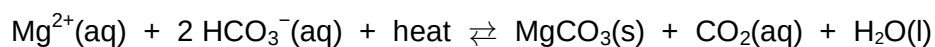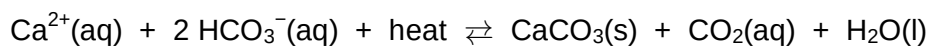**5.**   For the reverse reaction, the heat of reaction (ΔH) and the activation energy (E_a) are:

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

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

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

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

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

   A.   The activation 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.

7.   When bore water from limestone is boiled in an electric kettle a deposit of white boiler scale is usually observed on the inside of the kettle. The boiler scale is a deposit of both calcium carbonate and magnesium carbonate. The chemical reactions involved are:

$$Ca^{2+}(aq) + 2\ HCO_3^-(aq) + heat \rightleftarrows CaCO_3(s) + CO_2(aq) + H_2O(l)$$

$$Mg^{2+}(aq) + 2\ HCO_3^-(aq) + heat \rightleftarrows MgCO_3(s) + CO_2(aq) + H_2O(l)$$

Using these equations predict which of the following sets of conditions is most favourable to the formation of "Boiler scale".

	$[CO_2]$	Temperature
A.	low	high
B.	high	high
C.	low	low
D.	high	low

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8.   The equilibrium between $NO_2(g)$ and $N_2O_4(g)$ at 25^oC is described by the equation:
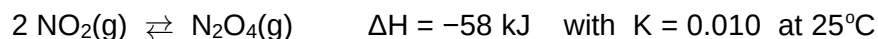
$$2 NO_2(g) \rightleftarrows N_2O_4(g) \qquad \Delta H = -58 \text{ kJ} \quad \text{with } K = 0.010 \text{ at } 25^oC$$

Answer **true** or **false** to these statements

Statements	True or False
$[N_2O_4]$ = 0.010 x $[NO_2]^2$ if system is at equilibrium at 25°C	
At 25°C and at equilibrium, the value of $[NO_2]^2/[N_2O_4]$ is constant	
At 47°C the K would be greater than 0.010	

(3 marks)

9.   The conversion of SO_2 to SO_3 is an important step in the Contact Process in the manufacture of H_2SO_4. The reaction for the conversion is:

$$2 SO_2(g) + O_2(g) \rightleftarrows 2 SO_3(g) \qquad \Delta H = -198 \text{ kJ}$$
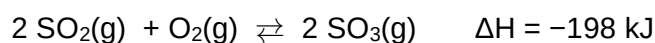
Complete columns 2 and 3 of this table when conditions listed in column 1 are applied to the system at equilibrium. You may assume that volume remians constant.

Merely write 'increase', 'decrease' or 'no effect' for your answers.

Imposed change	Rate of forward reaction at new equilibrium	Yield
Increased temperature		
Decreased pressure		
Add more air		

(6 marks)

10. Methanol, CH_3OH is prepared commercially by reacting CO and H_2 in the presence of Cr_2O_3 and ZnO. The equilibrium reaction is $CO(g) + 2 H_2(g) \rightleftarrows CH_3OH(g)$

(a) Write an expression for K

(b) What effect would the removal of the ZnO/Cr_2O_3 have on the:

(i) rate of the forward reaction _____

(ii) yield _____

(c) When the temperature is decreased, more CH_3OH is produced. Is the forward reaction endothermic or exothermic? _____

(d) What pressure (high / low) would you employ to get a high yield? _____

(1 + 2 + 1 + 1 = 5 marks)

11 (a) Explain fully why certain foods are placed in fridges.

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(3 marks)

(b) Consider the reaction: $2 SO_2(g) + O_2(g) \rightleftarrows 2 SO_3(g)$

At 23°C, K = 2.3 x 10^{-4} and at 87°C. K = 8.9 x 10^{-5}

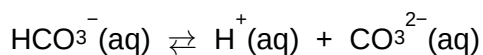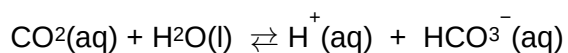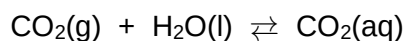Use this data to explain whether the forward reaction is exothermic or endothermic.

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(3 marks)

12. When carbon dioxide dissolves in water the following equilibria are established:

$$CO_2(g) + H_2O(l) \rightleftarrows CO_2(aq)$$

$$CO_2(aq) + H_2O(l) \rightleftarrows H^+(aq) + HCO_3^-(aq)$$

$$HCO_3^-(aq) \rightleftarrows H^+(aq) + CO_3^{2-}(aq)$$

Describe the effect that the following changes would separately have on the apparent solubility of carbon dioxide (use 'increase', 'decrease' or 'no change').
Give an explanation for each of you answers.

Change	Effect	Explanation
Adding more solid sodium carbonate		
Adding a solution of calcium nitrate		
Adding a dilute solution of sodium hydroxide		
Increasing the pressure		

(4 x 3 = 12 marks)

End of Test

Year 12 Chemistry   **Topic Test # 1 (Equilibrium) - 2012**

Name: ANSWERS   Mark = 39 / 39

Part 1: Multiple Choice Section   **7 marks**

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1. **C**   2. **C**   3. **B**   4. **B**   5. **C**   6. **D**   7. **A**

Part 2: Short Answer Section   **32 marks**

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8.   The equilibrium between $NO_2(g)$ and $N_2O_4(g)$ at 25°C is described by the equation:

   $$2\ NO_2(g) \rightleftarrows N_2O_4(g) \qquad \Delta H = -58\ kJ \quad with\ K = 0.010\ at\ 25°C$$
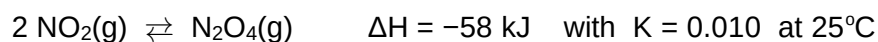
Answer **true** or **false** to these statements

Statements	True or False
$[N_2O_4] = 0.010 \times [NO_2]^2$ if system is at equilibrium at 25°C	**True**
At 25°C and at equilibrium, the value of $[NO_2]^2/[N_2O_4]$ is constant	**True**
At 47°C the K would be greater than 0.010	**False**

✓ **each**   (3 marks)

9.   The conversion of SO_2 to SO_3 is an important step in the Contact Process in the manufacture of H_2SO_4. The reaction for the conversion is:

   $$2\ SO_2(g)\ +\ O_2(g) \rightleftarrows 2\ SO_3(g) \qquad \Delta H = -198\ kJ$$
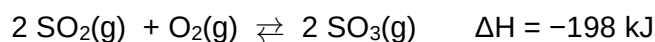
Complete columns 2 and 3 of this table when conditions listed in column 1 are applied to the system at equilibrium.

Merely write 'increase', 'decrease' or 'no effect' for your answers.

Imposed change	Rate of forward reaction at new equilibrium	Yield
Increased temperature	**increase**	**decrease**
Decreased pressure	**decrease**	**decrease**
Add more air	**increase**	**increase**

(6 marks)

10. (a) $K = \dfrac{[CH_3OH]}{[CO].[H_2]^2}$ ✔

(b) (i) decrease ✔

(ii) none ✔

(c) exothemric ✔

(d) high ✔ (1 + 2 + 1 + 1 = 5 marks)

11 (a) **At a lower tempoerature, reactants collide less frequently and a**

smaller proportion of molecules have sufficient E_K to overcome activation energy barrier. ✔✔

So the rate of reactions which lead to food spoillage decreases. ✔

(3 marks)

(b) **As temperature has increased, the value of K has also decreased** ✔

This indicates a shift to the left ($\downarrow[SO_3]$; $\uparrow[SO_2]$; $\uparrow[O_2]$) ✔

By LCP $\uparrow$T causes a shift in endothermic direction.
This means that reverse reaction is endothermic,
$\therefore$ forward reaction is exothermic ✔

(3 marks)

12.

Change	Effect	Explanation
Adding more solid sodium carbonate	**decrease**	$\uparrow[CO_3^{2-}]$ **$\therefore$ all equilibria shift left** **At new equilibrium less CO_2 will appear to be dissolved**
Adding a solution of calcium nitrate	**increase**	$\downarrow[CO_3^{2-}]$ **$Ca^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)$** **$\therefore$ all equilibria shift right** **At new equilibrium more CO_2 will appear to be dissolved**
Adding a dilute solution of sodium hydroxide	**increase**	$\downarrow[H^+]$ **$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$** **$\therefore$ all equilibria shift right** **At new equilibrium more CO_2 will appear to be dissolved**
Increasing the pressure	**increase**	$\uparrow[CO_2(g)]$ **$\therefore$ all equilibria shift right** **At new equilibrium more CO_2 will appear to be dissolved**

✔ **effect,** ✔✔ **explanation**   (4 x 3 = 12 marks)

End of Test