

## Part 1: Multiple Choice Section

7 marks

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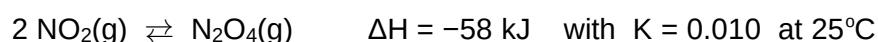
1. C 2. C 3. B 4. B 5. C 6. D 7. A

## Part 2: Short Answer Section

32 marks

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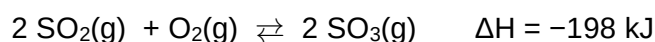
8. The equilibrium between
- $\text{NO}_2(\text{g})$
- and
- $\text{N}_2\text{O}_4(\text{g})$
- at
- $25^\circ\text{C}$
- is described by the equation:

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

Statements	True or False
$[\text{N}_2\text{O}_4] = 0.010 \times [\text{NO}_2]^2$ if system is at equilibrium at $25^\circ\text{C}$	<b>True</b>
At $25^\circ\text{C}$ and at equilibrium, the value of $[\text{NO}_2]^2/[\text{N}_2\text{O}_4]$ is constant	<b>True</b>
At $47^\circ\text{C}$ the K would be greater than 0.010	<b>False</b>

✓ each (3 marks)

9. The conversion of
- $\text{SO}_2$
- to
- $\text{SO}_3$
- is an important step in the Contact Process in the manufacture of
- $\text{H}_2\text{SO}_4$
- . The reaction for the conversion is:



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	<b>increase</b>	<b>decrease</b>
Decreased pressure	<b>decrease</b>	<b>decrease</b>
Add more air	<b>increase</b>	<b>increase</b>

(6 marks)

10. Methanol, CH<sub>3</sub>OH is prepared commercially by reacting CO and H<sub>2</sub> in the presence of Cr<sub>2</sub>O<sub>3</sub> and ZnO. The equilibrium reaction is  $\text{CO(g)} + 2 \text{H}_2\text{(g)} \rightleftharpoons \text{CH}_3\text{OH(g)}$

(a) Write an expression for K

$$K = \frac{[\text{CH}_3\text{OH}]}{[\text{CO}] \cdot [\text{H}_2]^2} \quad \checkmark$$

(b) What effect would the removal of the ZnO/Cr<sub>2</sub>O<sub>3</sub> have on the:

(i) rate of the forward reaction **decrease**  $\checkmark$

(ii) yield **none**  $\checkmark$

(c) When the temperature is decreased, more CH<sub>3</sub>OH is produced. Is the reaction endothermic or exothermic? **exothermic**  $\checkmark$

(d) What pressure (high / low) would you employ to get a high yield? **high**  $\checkmark$

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

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

**At a lower temperature, reactants collide less frequently and a smaller proportion of molecules have sufficient E<sub>K</sub> to overcome activation energy barrier.**  $\checkmark\checkmark$

**So the rate of reactions which lead to food spoilage decreases.**  $\checkmark$

(3 marks)

(b) Consider the reaction:  $2 \text{SO}_2\text{(g)} + \text{O}_2\text{(g)} \rightleftharpoons 2 \text{SO}_3\text{(g)}$

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

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

**As temperature has increased, the value of K has also decreased**  $\checkmark$

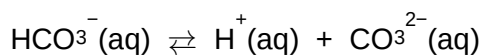
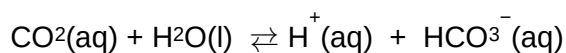
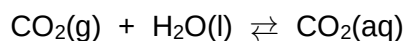
**This indicates a shift to the left ( $\downarrow[\text{SO}_3]$ ;  $\uparrow[\text{SO}_2]$ ;  $\uparrow[\text{O}_2]$ )**  $\checkmark$

**By LCP  $\uparrow T$  causes a shift in endothermic direction.**

**This means that reverse reaction is endothermic,  $\therefore$  forward reaction is exothermic**  $\checkmark$

(3 marks)

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



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 your answers.

<i>Change</i>	<i>Effect</i>	<i>Explanation</i>
Adding more solid sodium carbonate	<b>decrease</b>	$\uparrow[\text{CO}_3^{2-}]$ $\therefore$ all equilibria shift left At new equilibrium less $\text{CO}_2$ will appear to be dissolved
Adding a solution of calcium nitrate	<b>increase</b>	$\downarrow[\text{CO}_3^{2-}]$ $\text{Ca}^{2+}(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightarrow \text{CaCO}_3(\text{s})$ $\therefore$ all equilibria shift right At new equilibrium more $\text{CO}_2$ will appear to be dissolved
Adding a dilute solution of sodium hydroxide	<b>increase</b>	$\downarrow[\text{H}^+]$ $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$ $\therefore$ all equilibria shift right At new equilibrium more $\text{CO}_2$ will appear to be dissolved
Increasing the pressure	<b>increase</b>	$\uparrow[\text{CO}_2(\text{g})]$ $\therefore$ all equilibria shift right At new equilibrium more $\text{CO}_2$ will appear to be dissolved

✓ effect, ✓✓ explanation (4 x 3 = 12 marks)

**End of Test**