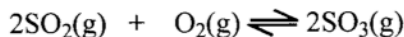


Practice Exam: Paper 2

Topic 7: Equilibrium

Topic 8: Acids & Bases

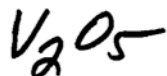
1. Consider the following reaction in the Contact process for the production of sulfuric acid for parts (a) - (d).



(a) Write the equilibrium constant expression for the reaction.

$$K_c = \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2[\text{O}_2]} \quad (1)$$

(b) (i) State the catalyst most often used in the Contact process. (1)



(ii) State and explain the effect of the catalyst on the value of the equilibrium constant and on the rate of the reaction.

A catalyst will increase both the forward and reverse rates of reaction by lowering E_a , but it will not effect the value of K_c . (2)

(c) Use the collision theory to explain why increasing the temperature increases the rate of the reaction between sulfur dioxide and oxygen.

more effective collisions with sufficient activation energy (E_a). (2)

(d) Using Le Chatelier's principle state and explain the effect on the position of equilibrium of

(i) increasing the pressure at constant temperature.

Reaction will shift to the right to decrease the overall pressure (fewer moles of gas) (2)

(ii) removing of sulfur trioxide.

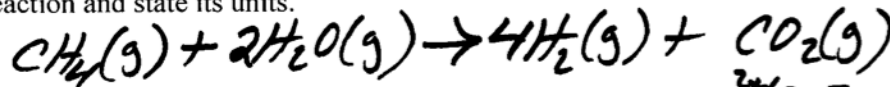
Shifts to the right to produce more SO_3 . (2)

(iii) using a catalyst.

No effect, a catalyst will only increase the reaction rate. (2)

2. In the gaseous state, methane and steam react to form hydrogen and carbon dioxide.

(i) Write an equation for this endothermic equilibrium reaction. Deduce the equilibrium expression for the reaction and state its units. (2)



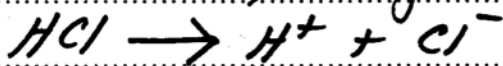
$$K_c = \frac{[\text{H}_2]^4[\text{CO}_2]}{[\text{CH}_4][\text{H}_2\text{O}]^2}; \text{ units} = \frac{[\text{mol}^4 \text{L}^{-4}][\text{mol} \text{L}^{-1}]}{[\text{mol} \text{L}^{-1}][\text{mol}^2 \text{L}^{-2}]} = [\text{mol}^2 \text{L}^{-1}] = \boxed{\text{mol}^2 \text{dm}^{-3}} \quad (= \frac{\text{mol}^2}{\text{L}^2})$$

(ii) State the conditions of temperature and pressure under which the forward reaction is favoured. (1)

High Temperature (rxn is endothermic)
Low pressure (products have fewer moles of gas) (1)

3. Define the terms *strong acid* and *weak acid*. Using hydrochloric and ethanoic acid as examples, write equations to show the dissociation of each acid in aqueous solution.

Strong acids completely ionize



Weak acids only partially ionize



(3)

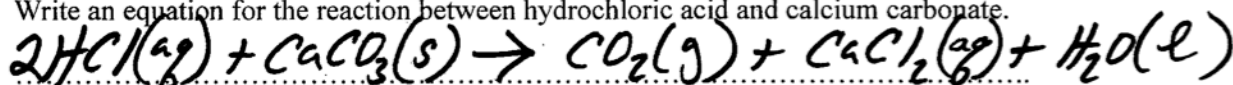
4. (i) Calcium carbonate is added to separate solutions of hydrochloric acid and ethanoic acid of the same concentration. State **one** similarity and **one** difference in the observations you could make.

Similarity: Both acids will react with CaCO_3 , producing a gas (or bubbles).

Difference: HCl would produce a more vigorous reaction, as it's a strong acid.

(2)

- (ii) Write an equation for the reaction between hydrochloric acid and calcium carbonate.



(phases not needed!)

(2)

- (iii) Determine the volume of $1.50 \frac{\text{mol}}{\text{dm}^3}$ hydrochloric acid that would react with exactly 1.25 g of calcium carbonate.

$\frac{\text{L}}{\text{dm}^3} \leftarrow$ to make work more familiar

$$1.25 \text{ g CaCO}_3 \times \frac{1 \text{ mol}}{100.09 \text{ g}} \times \frac{2 \text{ mol HCl}}{1 \text{ mol CaCO}_3} \times \frac{1 \text{ L}}{1.50 \text{ mol HCl}} =$$

(Recall, $1 \text{ dm}^3 = 1 \text{ L}$)

$$0.0167 \text{ L}$$

$$= \boxed{0.0167 \text{ dm}^3}$$

- (iv) Calculate the volume of carbon dioxide, measured at 273 K and $1.01 \times 10^5 \text{ Pa}$, which would be produced when 1.25 g of calcium carbonate reacts completely with the hydrochloric acid.

$$1.25 \text{ g CaCO}_3 \times \frac{1 \text{ mol}}{100.09 \text{ g}} \times \frac{1 \text{ mol CO}_2}{1 \text{ mol CaCO}_3} \times \frac{22.4 \text{ L}}{\text{mol}} = 0.280 \text{ L}$$

$$= \boxed{0.280 \text{ dm}^3}$$

(Note: $101.3 \text{ kPa} = 1.01 \times 10^5 \text{ Pa}$)

↑
ignore

(2)

5. The pH values of solutions of three organic acids of the same concentration were measured.

acid X	pH = 5
acid Y	pH = 2
acid Z	pH = 3

(i) Identify which solution is the least acidic.

acid X

(1)

(ii) Deduce how the $[H^+]$ values compare in solutions of acids Y and Z.

The $[H^+]$ for ^{acid} Y is 10 times more concentrated than acid Z.

(2)

(iii) Arrange the solutions of the three acids in decreasing order of electrical conductivity, starting with the greatest conductivity, giving a reason for your choice.

Y > Z > X

The stronger the acid, the greater the concentration of H^+ .

(i.e., ions increase electrical conductivity)

(2)

6. The equilibrium reached when ethanoic acid is added to water can be represented by the following equation:



Define the terms Brønsted-Lowry acid and Lewis base, and identify two examples of each of these species

A Brønsted-Lowry acid is a proton donor.

Examples: CH_3COOH and H_3O^+

A Lewis base is an electron pair donor.

Examples: H_2O and CH_3COO^-

(3)

7. Identify **one** example of a strong acid and **one** example of a weak acid. Outline **three** different methods to distinguish between equimolar solutions of these acids in the laboratory. State how the results would differ for each acid.

i.e., same concentration

Strong Acid: HCl (or HBr , HNO_3 , $HClO_4$, HI , H_2SO_4)

Weak Acid: H_2CO_3 (or CH_3COOH , HCN , ... nearly any other acid!)

Methods to distinguish:

1.) HCl would have a lower pH

2.) Electrical conductivity would be greater for HCl

3.) HCl would react more vigorously with Mg (or $CaCO_3$, ...) than would H_2CO_3 , producing more gas bubbles and heat in a shorter period of time.

(3)