Lesson 4 For Book 2

Exercise 1 *Review for calculation for titration*

A student carried out the following experiment to determine the concentration of ethanoic acid in a brand of **commercial vinegar**. '25.0 cm$^3$ of the vinegar was placed in apparatus Y and was then diluted to 250.0 cm$^3$ with distilled water. 25.0 cm$^3$ of the diluted vinegar solution was withdrawn and titrated against 0.10 M sodium hydroxide solution with **phenolphthalein** as indicator.' (Vineagar is a weak acid)

(1)   (i) Name apparatus Y.

(ii) Suggest ONE reason for diluting the vinegar.

(2)   State the colour change at the end point of the titration.

(3)   The student carried out four trials altogether. The titration results are listed in

| Titration / Burette reading | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Final reading (cm$^3$) | 23.90 | 23.60 | 23.10 | 23.60 |
| Initial reading (cm$^3$) | 3.00 | 3.50 | 3.10 | 3.40 |

(4) Based on the titration results, calculate a *reasonable* average for the volume of the sodium hydroxide solution used.

(5) Calculate the concentration, in mol dm$^{-3}$, of ethanoic acid in the vinegar.

(20.1 cm$^3$, 0.804M)

Rate of Reaction

● In Chemistry, there are two main stream which are **Energetics** (about erengy e.g how much heat is released) and **Kinetics** (about *rate* of reaction).

● **Rate** of reaction tells us how quickly a chemical reaction occurs. For a specific reaction, if reactant A$_1$ and reactant B react faster than A$_2$ and reactant B, we can deduce that ____ is more reactive than ____.

→ Rate of reaction measures the r_____ of a reactant towards a reaction. (in the same reaction conditions, e.g p_____, t_____, c_____)

→ Theoretically, rate of a reaction relates to the E$_a$ (a_____ energy) of the reaction, where E$_a$ is the minimum K.E. required for the reactants to start the reaction. If A$_1$ can react with B faster, Ea of the reaction between A$_1$ and B is l_____ than that between A$_2$ and B.          --- rate $\propto$ 1/E$_a$

● Study of rate includes :

1.   **Average rate** = <u>Total change in **quantity** of a reactant/product</u>

Total ____ taken for the reaction

→ For a reactant, [R] must be _____. ; For a product, [P] must be _____

→ How can we know the end of the reaction? (Indeed, we can't know.)

2.   **Instantaneous rate** = the rate at an instant of the reaction

(*found by the drawing of a tangent line at a time on the **rate curve***)

*What factors affect rate of reaction?*

1)  Temperature  2)  Pressure  3)  Surface area

4)  Presence of **catalyst** (positive catalyst can _____ the rate of reaction;

                    while negative catalyst can decrease the rate of reaction)

5)  Concentration of the species

How can we monitor the progress of a reaction?

--- Chemical means

*Titrimetric analysis (For acid / base involving reaction)*

i)  Start the reaction and the stop watch together at a **thermostatic** water bath

ii)  **Extract** a specific amount of reaction mixture by using p_____ at a regular

time interval.

iii)  **Quench/Stop** the reaction by physical means (e.g. cooling in ice/water? bath ) or

chemical means (e.g. Kill one of the reactants / products by adding base if the reaction

mixture contains an ____ )

iv) Find out the concentration of a reactant/product by A-B titration

(e.g. $CaCO_3 + 2\ HCl \rightarrow CaCl_2 + CO_2 + H_2O$ , you should find out the [    ] )

v) Plot a graph of variation of [R]/[P] againt the time interval you chosen (e.g 5mins)

→ *Upward curve* for [   ] against time ; *downward curve* for [   ] against time

--- Physical means

*1)   Measurement of the change of volume of the reaction mixture*

    For reaction involving g_____ reactant/product? only.

→ Volume will increase if you plot a graph of [P (g)] against time.

→ This method requires gas s_____ to monitor the change of volume.

Exercise 2      Given that coral consists of *Calcium Carbonate* only.
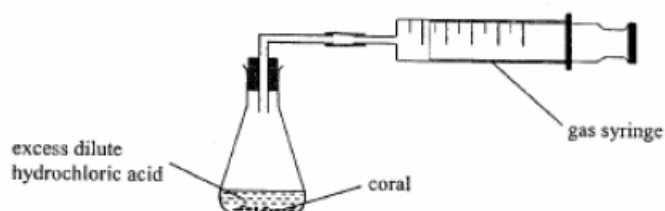


a)  Write down the equation for the

    chemical reaction.

b)  Suggest another method to monitor

    the progress of reaction.

*2)   Measurement of the change of pressure of the reaction mixture*

    For reaction involving insoluble g_____ reactant or product. A pressure sensor is

used.

→ Pressure will increase if you plot a graph of [P (g)] against time.

*3)*    *Measurement of the change in mass of the reaction mixture*

For reaction involving g_____ product. The change in mass of the reaction mixture is caused by the escape of gaseous product.

→ The reaction mixture is put on an *electric balance* until the reaction is thought to be ended. e.g Consider the reaction between *sodium carbonate and HCl*, how can you determine whether the reaction is ended? The release of gas b_____ will stop.

*4)*    *Measurement of the change of the colour intensity of the reaction mixture*

For reaction involving **one coloured species**. A **colorimeter** is required to measure the change in **color absorbance** of the mixture.      i.e. color absorbance $\propto$ conc.

| |
|---|
| If the coloured species is the reactant, [R] drops with the color absorbance. |
| If the coloured species is the product, [P] _____ with the color absorbance. |

*5)*    *Measurement of the change of the transmittance (透光度) of the reaction mixture*

Such reaction is called CLOCK experiment. It involves the formation of insoluble and "light-blockening" product.

e.g. The common clock reaction between thiosulphate ($S_2O_3{}^{2-}$) and an acid. Insoluble yellow sulphur is formed to block the cross drawn on the paper.

$$S_2O_3{}^{2-} + 2H^+ \rightarrow SO_2 + H_2O + S \text{ (s)}$$

But = the observation for the blockening of the cross is subjective

→ different result for different students doing the same reaction may be obtained.

→ uncertainties existing in measuring the time for the complete blockening.

## Further Notes about rate of reaction

1. You will find that titration is a very fast process, i.e. neutralization is a fast reaction, (end point can be reached within five minutes); however, redox reaction e.g. r_____ of iron is a very slow process. It is because $E_a$ of neutralization is near to zero.

2. Theoretically, a reaction will not stop. It continues with the rate reducing to_____.

3. Rate of reaction can be explained by the Collision theory

    → rate of reaction is related to the frequency of collision between r_____

      i.e. rate $\propto$ the frequency of collision.

    → frequency of the collision is related to the _____ energy of reactants.

    → A reaction will start if and only if K.E. of reactants = / > ___ of the reaction and the reactants collide in correct position.

Exercise 2    *Rate of reaction*

Two different samples of calcium carbonate (*A* and *B*), each weighing 0.8 g and containing **inert impurities**, were allowed to react with excess dilute hydrochloric acid *under the same laboratory conditions*. The volumes of carbon dioxide gas evolved with time are shown in the graph:

(i)   Explain why we need perform the experiment under the same lab. conditions?
→ To perform a f_____ test.

(ii)  Explain why the slope of the curve for sample *A* is steeper at *X* than at *Y*.
→    The c_____ of the $CaCO_3$ is higher at point ___ than at ___

(iii) From the two curves, deduce *TWO* differences between sample *A* and sample *B*.
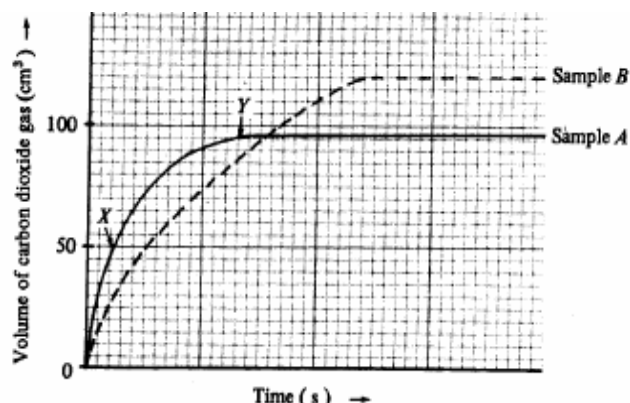a)
b)



(iv)  (1)   What is the total volume of gas liberated from sample *B*?    → _____
      *** (2)    Hence, calculate the percentage of calcium carbonate in sample B.
      (Molar volume of gas under the laboratory conditions = 24 dm$^3$)

($120 \text{ cm}^3$, 62.5%)

Pre-Talk on organic chemistry --- Hydrocarbons from fossil fuels

● Organic chemistry is the study of organic compounds which contains ___and___

● Some useful organic compounds are called fossil fuels as they are formed from the remains of organisms, e.g Coal, petroleum → fuels will give us e_____.

● Such "pre-fuels" extracting from the underground is a mixture and thus we need to perform oil refining by f_____ distillation, which is a p_____ process → not involves bond breaking or forming.

● During fraction distillation, **smaller hydrocarbons/fuels** with lower no. of carbons will be collected first as they have a l_____ boiling point (why?).
  → they will have a cleaner/paler color and lower viscosity. (Why?)
  → they are e_____ to burn and hence said to be a cleaner fuel. (Why?)
  → boiling point, viscosity and ease of burning is a measure of intermolecular force, i.e. van _____ _____ force. Hydrocarbons with a lower no. of carbons will have a w_____ intermolecular force as the chance to contact with another molecule is lower than in the case of large hydrocarbons. (contact surface area is smaller.)