Unit 12

(1) **1983 A/L**

a) Following is the trend of depleting radioactivity of a 10 g sample of an element *X*.

i) What is the half – life of the element?

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ii) Draw the expected graph for the trend of wasting of radioactivity for a sample of 5 g of *X* in the same graph.

iii) What is the time needed to reduce a 5 g of element *X*, to 625 mg?

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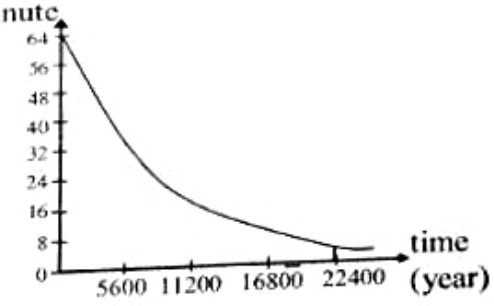

(2) **1998 A/L**

c) Name the factors that influence the rate of a chemical reaction.

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(3) **2002 A/L**

c) i) What are the basic requirements that must be satisfied by the reactant molecules for any chemical reaction to occur?

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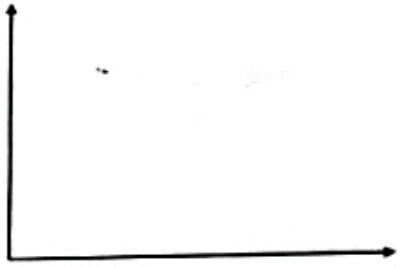
Sketch the Boltzmann distribution for the molecules of a given gas at temperatures T_1 and T_2 where $T_2 > T_1$ Label your diagram / graph fully.



ii) Consider the reaction

$2H_2(g) + O_2(g) \longrightarrow 2H_2O(g)$ □ H =- 490 kJ

and explain the following parts (A) and (B).

A) A mixture of $H_2(g)$ and $O_2(g)$ is stable at room temperature. However the mixture reacts rapidly when a small amount of platinum powder is added to it.

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B) This reaction is often accompanied by an explosion.

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d) This part is related to the experiment for the determination of the order of the reaction between thiosulphate ions and hydrochloric acid.

i) Write down the balanced chemical equation for the reaction studied in this experiment.

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ii) Describe how a measure of the rate of the reaction is obtained in this experiment.

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(4) **2004 A/L**

b) Recall the experiment to determine the order with respect to $Fe^{3+}(aq)$, in the reaction between $Fe^{3+}(aq)$ and KI.

Table I gives the volumes (in cm^3) and concentration of the reagents used for four different measurements

Table I

Experiment number	water	0.100 mol dm^{-3} acidified $Fe^{3+}(aq)$ solution	1 mol dm^{-3} KI solution	0.0001 mol dm^{-3} $Na_2S_2O_3$ solution containing starch
1	-	25.00	5.00	5.00
2	5.00	20.00	5.00	5.00
3	10.00	15.00	5.00	5.00
4	15.00	10.00	5.00	5.00

All experiments were carried out at room temperature by three groups of students *A*, *B* and *C*. The reagents were measured into two beakers before mixing. The way in which the three student groups measured the reagents in the two beakers is given in table II. The stopwatch was started at the time the contents of the two beakers were mixed, to determine the time for a blue colour to appear.

Table II

Group	Beaker 1	Beaker 2
A	KI solution	all other solutoins
B	$Na_2S_2O_3$ solution	all other solutoins
C	$Fe^{3+}(aq)$ solution	all other solutoins

Answer the following questions.

i) Why is the same amount of $Na_2S_2O_3$ used in these experiments?

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ii) What is the role of starch in this experiment?

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iii) One of the three groups followed the correct procedure. In the following table, write in the appropriate cage the word 'correct' to identify this group. In the other two cages give the main reasons for the method followed by the relevant group being unacceptable.

A	
B	
C	

iv) The group which followed the correct procedure found that the time taken for the appearance of the blue colour in experiment number 1, was too short to be measured. Write three ways in which the time taken for the colour change may be increased.

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(5) **2006 A/L**

b) The ester $R_1 - \overset{O}{\overset{\|}{C}} - OR_2$ is a crystalline solid. R_1 and R_2 are hydrocarbon chains. This ester undergoes hydrolysis to give the following equilibrium.

$R_1COOR_2(s) + H_2O(l) \rightleftharpoons R_1COOH(aq) + R_2OH(aq)$

The statements given below refer to a procedure for the hydrolysis of the ester. Fill in the blanks in the statements using only suitable words / phrases, selected from the list given below. The same word / phrase may be used more than once. Each blank should be filled with one word only. List of words / phrases to be used:

activation energy, boiling point, carboxylic acid, catalysts, concentration, contact, decreases, density, equilibrium, increases, left, mixing, organic compound, rate, right, slowly, sodium salt, solid, yield.

i) The ester is ground to a fine powder.
Grinding ..... the surface area of the solid. This leads to an increase in the ..... between reactants.

ii) The rate of hydrolysis can be increased by using acids or bases. Hydrolysis by water alone occurs ..... due to the high ..... of the reaction. Acids and bases act as ..... for this reaction.

iii) Aqueous NaOH is more suitable than aqueous HCl for the above hydrolysis. Acid hydrolysis gives an ..... mixture of products and reactants. Hence the amount of product obtained is limited by the ..... concentrations. When base is used, the carboxylic acid formed on hydrolysis is removed from the ..... mixture as the ..... . The equilibrium is thus pushed to the ..... and the ..... is increased.

iv) The powdered ester is stirred with dil. NaOH and heated to 60°C to complete the hydrolysis. Stirring helps to increase ..... between reactants and heating increases the ..... of the reaction.

v) After complete hydrolysis, when excess NaCl is dissolved in the reaction mixture, a white solid separates and rises to the top.
Dissolved NaCl increases the ..... of ions in solution. Under these conditions the less soluble ..... of the carboxylic acid separates. As the dissolved NaCl also increases the ..... of the solution, the solid rises to the top.

(6) 2015 A/L

a) The kinetics of the following can be studied by measuring initial rates.

A(aq) + 5B(aq) + 6C(aq) → 3D(aq) + 3E(aq)

Four experiments carried out by changing initial concentrations of *A*, *B* and *C* at a give temperature are described in the following table. $[\Delta A]_0$ the change in concentration of *A*. with time (t/s) was measured.

Expt.	$[A]_0$ / mol dm^{-3}	$[B]_0$ / mol dm^{-3}	$[C]_0$ / mol dm^{-3}	$[\Delta A]_0$ / mol dm^{-3}	t/s	Initial Rate (*R*) / mol dm^{-3} s^{-1}
1	0.2	0.2	0.2	0.040	50	R_1=.....
2	0.4	0.2	0.2	0.069	60	R_2=.....
3	0.4	0.4	0.2	0.128	40	R_3=.....
4	0.2	0.2	0.4	0.080	25	R_4=.....

i) Calculate initial rates R_1, R_2, R_3 and R_4 and complete the table.

ii) Taking a, b and c as order with respect to each of the reactants *A*, *B* and *C* respectively, and the rate

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iii) State the overall order of the reaction

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iv) Calculate the rate constant *k* of the reaction'

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b) i) I. **In another experiment. If the concentrations are. $[A]_0 = 1.0 \times 10^{-3}$ mol dm^{-3}, $[B]_0 = 1.0$ mol dm^{-3} and $[C]_0 = 2.0$ mol dm^{-3}, show that the rate expression for the reaction can be given by Rate = $k^1[A]^a$ (k^1 is the rate constant of the reaction under these conditions.)**

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II. **State the assumption(s) made in deriving the expression on I above.**

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ii) In the above b) i) experiment, the concentration of *A*, [A], changes with time (t) according to the following equation. $2.303 \log [A] = -k't + 2.303 \log [A]_0$. ($[A]_0$ is the initial concentration of *A*.) Show that the half – life ($t_{1/2}$) of the reaction is given by $0.693/k'$ and calculate ($t_{1/2}$) by using the data in a) iv) and b) i) above.

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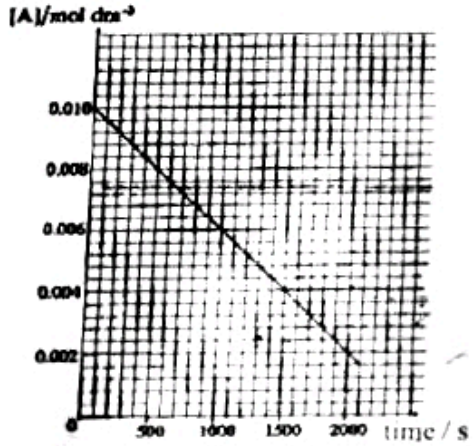
(7) **2016 A/L**

a) When 0.010 moles of gas A is placed in a 1.0 dm^3 evacuated closed rigid container in the presence of a small of a solid catalyst, at 227°C, it decomposes as shown below.

$$A(g) \longrightarrow B(g) + C(g)$$

The concentration of A(g) was measured over time. The results are shown in the following graph.



i) **Taking** the order and the rate constant of the reaction as a and k. respectively. **Write** the rate expression for the **above reaction.**

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ii) **Giving** reasons, determine the value of *a*

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iii) Calculate the rate constant, k at 227°C

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iv) Calculate the pressure in the container when half the initial amount of A(g) has decomposed. Assume that the volume of the catalyst can be neglected.

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b) In the presence of a solid catalyst, the gas X decomposes according to the following chemical equation.

$$\mathbf{X}(g) \xrightarrow[\Delta]{\text{Catalyst}} 2\mathbf{Y}(g) + \mathbf{Z}(g)$$

1.0 mole of gas X was introduced to an evacuated container. The initial volume of the gas was measured to be V_0. The reaction was initialed by introducing a small amount of catalyst (volume is negligible). The rate constant of the catalyzed reaction is k_1 and order of the reaction with respect to X is b. The initial rate of the reaction was measured as R_0. The pressure of the system was maintained at a constant value by allowing the container to expand. The temperature of the system was also maintained at a constant value.

i) Write an expression for R_0 using the terms b, k_1 and $V0$

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ii) It was observed that the rate of the reaction was 0.2 R_0 and the volume of the container was doubled when 50% of X(g) was consumed. Calculate the order b of the reaction.

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