Chemical Kinetics

<table>
<tr><th>Q.No.</th><th>Question</th><th>Marks</th></tr>
<tr><td>11</td><td>Shamoita compiled a list of rate expressions for several reactions she studied during her lab classes:

I. Rate = $k [P]^{3/2} [Q]^{-1}$

II. Rate = $k [P]^{1} [Q]^{1}$

III. Rate = $k [P]^{1} [Q]^{0}$

Which of the following arranges the reactions in the increasing order of their overall reaction order?

(A) I, II, III
(B) I, III, II
(C) II, III, I
(D) III, II, I

[Skill: Application]</td><td>1</td></tr>
<tr><td>12</td><td>During hydrolysis of ethyl acetate, the order of the reaction changes from ____________ to ________________ when the amount of water is reduced considerably.

[Skill: Mechanical]</td><td>1</td></tr>
<tr><td>13</td><td>Carbon dating is a technique used by archaeologists to determine the age of organic materials, such as trees, plants, animal remains, and human artifacts made from wood and leather, by measuring the amount of carbon-14 present.

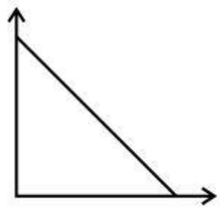
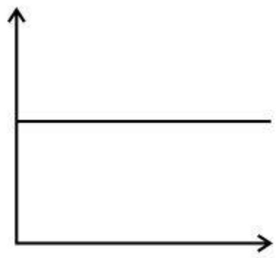
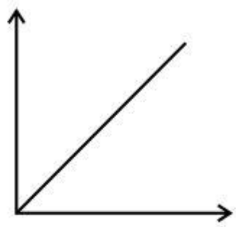
An archaeologist discovered that the carbon-14 content in the remains of an animal was 25% of the original carbon-14 present in the plant’s body when it died.

What is the age of this sample?

(Given the half-life of carbon-14= 5730 years and log 4 = 0.6)

[Skill: Mechanical]</td><td>2</td></tr>
</table>

14 Redraw the graphs labelling the axes correctly: (3)

Order of the reaction	Graph
ZERO	
ZERO	
FIRST	

[Skill: Application]

15 (3+2)

(a) How is the time required for 90% completion of a first-order reaction related to its half-life?

(b) Draw Maxwell-Boltzmann curve showing the distribution for temperatures T_1(70°C) and T_2(80°C) for a sample of nitrogen gas.

[Skill: Understanding]

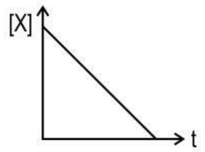
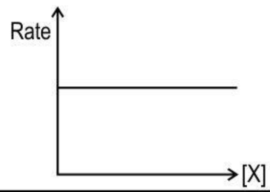
Marking Scheme

<table>
<tr><td>Q No.</td><td>Rubric</td><td>Marks</td></tr>
<tr><td>11</td><td>Correct Answer: B
To determine the overall reaction order for each of the reactions listed, we need to sum the exponents of the concentrations in the rate expression for each reaction.
order of I = ½; order of II = 2; order of III= 1.</td><td>1</td></tr>
<tr><td></td><td>A: Students choosing this option may lack the understanding that order of a reaction is the sum of powers of the concentration of the reactants in the rate law expression is called the order of that chemical reaction.</td><td></td></tr>
<tr><td></td><td>C: Students choosing this option may have got confused about the mode of arranging the reactions.</td><td></td></tr>
<tr><td></td><td>D: Students choosing this option may lack the understanding that order of a reaction is the sum of powers of the concentration of the reactants in the rate law expression is called the order of that chemical reaction.</td><td></td></tr>
<tr><td>12</td><td>During hydrolysis of ethyl acetate, the order of the reaction changes from pseudo first order to second order when the amount of water is reduced considerably.</td><td>1</td></tr>
<tr><td>13</td><td>Decay of ^{14}C is a first order reaction.

=> $k = 0.693/ t_{1/2} = 0.693 / 5730$ [0.5 marks]

=> $t = (2.303/k) \log(A_0/A)$ [0.5 marks]

=> $t = (2.303 \times 5730/0.693) \times \log 100/25$

=> t = 11425.27 years (approx.) [1 mark]</td><td>2</td></tr>
<tr><td>14</td><td>
<table>
<tr><th>Order of the reaction</th><th>Graph</th></tr>
<tr><td>ZERO</td><td>
</td></tr>
<tr><td>ZERO</td><td>
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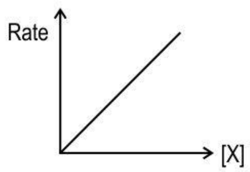
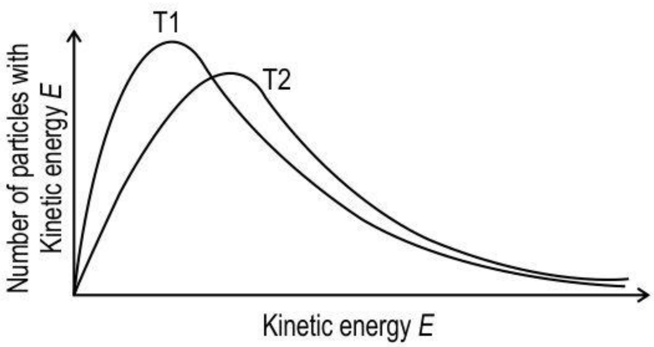
<tr><td>FIRST</td><td>
</td></tr>
</table>

[X] - represents concentration of the reactant.

[Award 1 mark for each correct answer.]

[Accept any other valid answer.]</td><td>3</td></tr>
</table>

15	(a) For a first-order reaction, the time required to complete a certain fraction of the reaction can be calculated using the integrated rate law: $t = (1/k)\ln([A]_0/[A])$ -----(i) *[0.5 marks]* where: t = time k = rate constant $[A]_0$ = initial concentration [A] = remaining concentration at time t To find the time for 90% completion, $[A] = 0.1[A]_0$. *[0.5 marks]* Substituting in eqn (i), $t_{90\%} = (1/k)\ln([A]_0/[A]) = (1/k)\ln([A]_0/0.1[A]_0) = (1/k)\ln 10$ ------(ii) *[0.5 marks]* For a first-order reaction, the half-life is: $t_{1/2} = \ln 2/k$ ------(iii) *[0.5 marks]* Dividing (ii)/(iii), $t_{90\%}/t_{1/2} = \ln 10/\ln 2 = 2.303/0.693$ *[0.5 marks]* =3.32*[0.5 marks]* Thus, the time for 90% completion of a first-order reaction is approximately 3.32 times the half-life.	3
	(b)  *[0.5 marks for the labelling of each axes and 0.5 mark for each curve with correct labelling with temperature]*	2