Chemistry 30

Rates of Reaction: Chemical Kinetics 50

I. Multiple Choice 20

1. C
2. B
3. A
4. B
5. C
6. D
7. D
8. B
9. C
10. A
11. B
12. A
13. C
14. A
15. D
16. D
17. D
18. A
19. A
20. A

II. Short Answer 30

1. Use the collision theory to explain why is a lump of sugar satisfactory to use in a hot cup of tea, but granulated sugar is better to use in iced tea.

2

In hot tea a lump of sugar dissolves quickly because of the temperature – reaction rates (dissolving) are faster with the increased temperature of the hot tea. Two reasons explain this – particles are moving faster so will collide more often, and the particles have more energy so more particles will have sufficient energy for a successful collision (the activation energy)

In cold tea granulated sugar is used – the greater surface area of the granulated sugar will increase dissolving rate because more sugar particles are exposed to the water.

2. A group of educators wish to have the scientist Jane Goodall give a lecture to a group of teachers on the behavior of chimpanzees. One of the educators knows Dr. Goodall personally and goes to an adjacent office to telephone her agent in New York City. The agent has her secretary write a note to Dr. Goodall. The note is typed and faxed to Africa. The fax is placed in an envelope when it is received and given to a messenger who must travel a few kilometres by boat and a few hundred metres on foot before handing the message to Dr. Goodall. The messenger returns to the messenger office with the reply and the process is reversed. Which is the rate-determining step in this process?

The rate determining step is the slowest step – the messenger's portion of the trip. **2**

3. The rate of disappearance of HCl was measured for the following reaction:

$$CH_3OH_{(aq)} + HCl_{(aq)} \rightarrow CH_3Cl_{(aq)} + H_2O_{(l)}$$

The following data was collected:

Time (min)	Concentration [HCl] (M)
0.00	1.85
79.0	1.67
158.0	1.52
316.0	1.30
632.0	1.00

a. Calculate the rate of the reaction for the following time periods:

i. for the first 79.0 minutes of the reaction (from time 0.00 to 79.0) **2**

$$\frac{\Delta \text{ concentration}}{\Delta \text{ time}} = \frac{1.85 - 1.67}{0 - 79.0} = 2.3 \times 10^{-3} \frac{\text{mol}}{\text{min}}$$

ii. for the last 316 minutes of the reaction (from time 316.0 to 632.0). **2**

$$\frac{1.30 - 1.00}{316 - 632} = \frac{0.30}{316} = 9.49 \times 10^{-4} \frac{\text{mol}}{\text{min}}$$

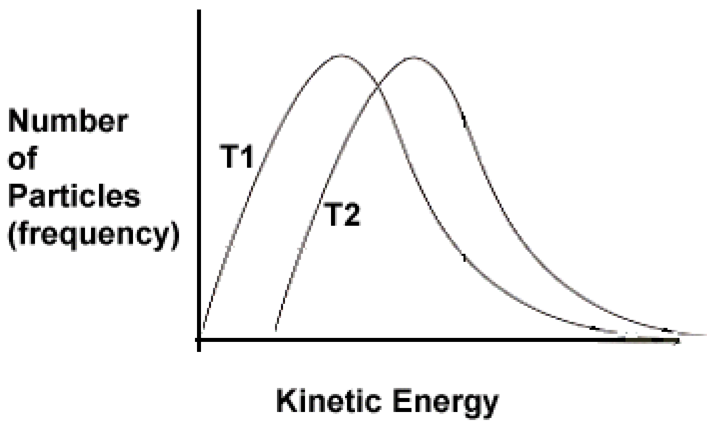
b. What happened to the rate of reaction – did it speed up, slow down, or stay the same? Why?

2

The rate slowed down, from 2.3×10^{-3} mol·min^{-1} to 9.49×10^{-4} mol·min^{-1}.

The rate slowed down as the reactants got used up – as the concentration decreases there are fewer particles to collide, thus slowing down reaction rate.

4 Consider the following kinetic energy curve for a particular reaction:



T1 is the original kinetic energy curve..

T2 is the new curve – the entire graph shifts to the right as all particles have more energy at the higher temperature.

On the diagram above, draw a line that would represent the same reaction carried out at a higher temperature. **2**

5. Which of the following three reactions, which one would you predict to be the fastest? Explain. **2**

a. C_3H_8 (g) + 5 O_2 (g) $\rightarrow$ 3 CO_2 (g) + 4 H_2O (l)

b. Zn^{2+} (aq) + S^{2-} (aq) $\rightarrow$ ZnS (s)

c. Zn (s) + S (s) $\rightarrow$ ZnS(s)

Reaction b will be the fastest – the reaction between ions in solution. There are no bonds to be broken (more-or-less – see Unit 4: Solutions). Reaction a involves the breaking off covalent bonds; reaction c involves solid reactants.

6. Consider the following reaction: 3 NO (g) $\rightarrow$ N_2O (g) + NO_2 (g)

If the rate of production of NO_2 gas is 0.040 mol · L^{-1} · s^{-1}, what would be the rate of loss of NO gas?

rate NO = $\frac{3\ \text{NO}}{1\ \text{NO}_2} \times$ **(0.040) = 0.12 mol · L^{-1} · s^{-1}**

7. The following mechanisms has been proposed for the reaction between chloroform, $CHCl_3$, and chlorine.

   a. Determine the overall equation for this reaction **2**

Step 1:	Cl_2 (g)	→	2 Cl (g)	**fast**
Step 2:	Cl (g) + $CHCl_3$ (g)	→	HCl (g) + CCl_3 (g)	**slow**
Step 3:	Cl (g) + CCl_3 (g)	→	CCl_4 (g)	**fast**
OVERALL:	**Cl_2 + $CHCl_3$**	**→**	**HCl + CCl_4**	

   b. Identify the reaction intermediates for the reaction (there are two) **2**

   Reaction intermediates are Cl and CCl_3

   c. Which step is the rate determining step? **1**

   The rate determining step is the slowest step – step 2

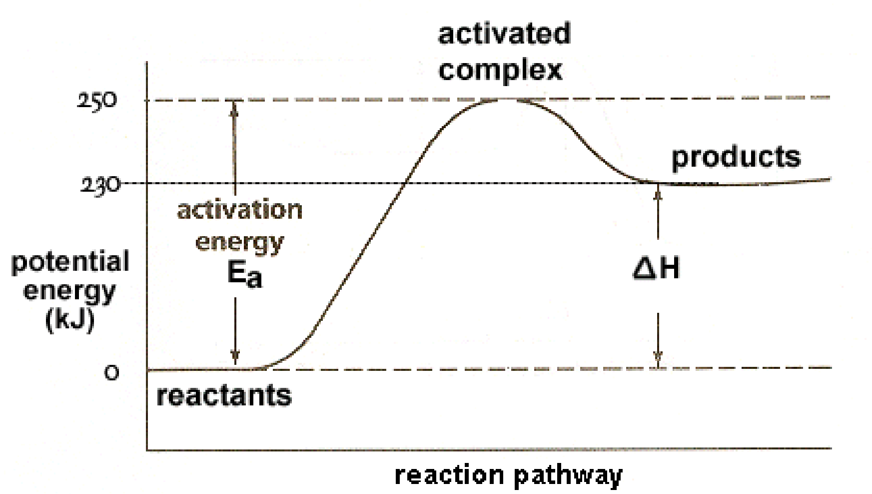
8. Consider the following reaction: **6**

   2 C(s) + H_2(g) + 230 kJ → C_2H_2(g) E_a for forward reaction = 250 kJ

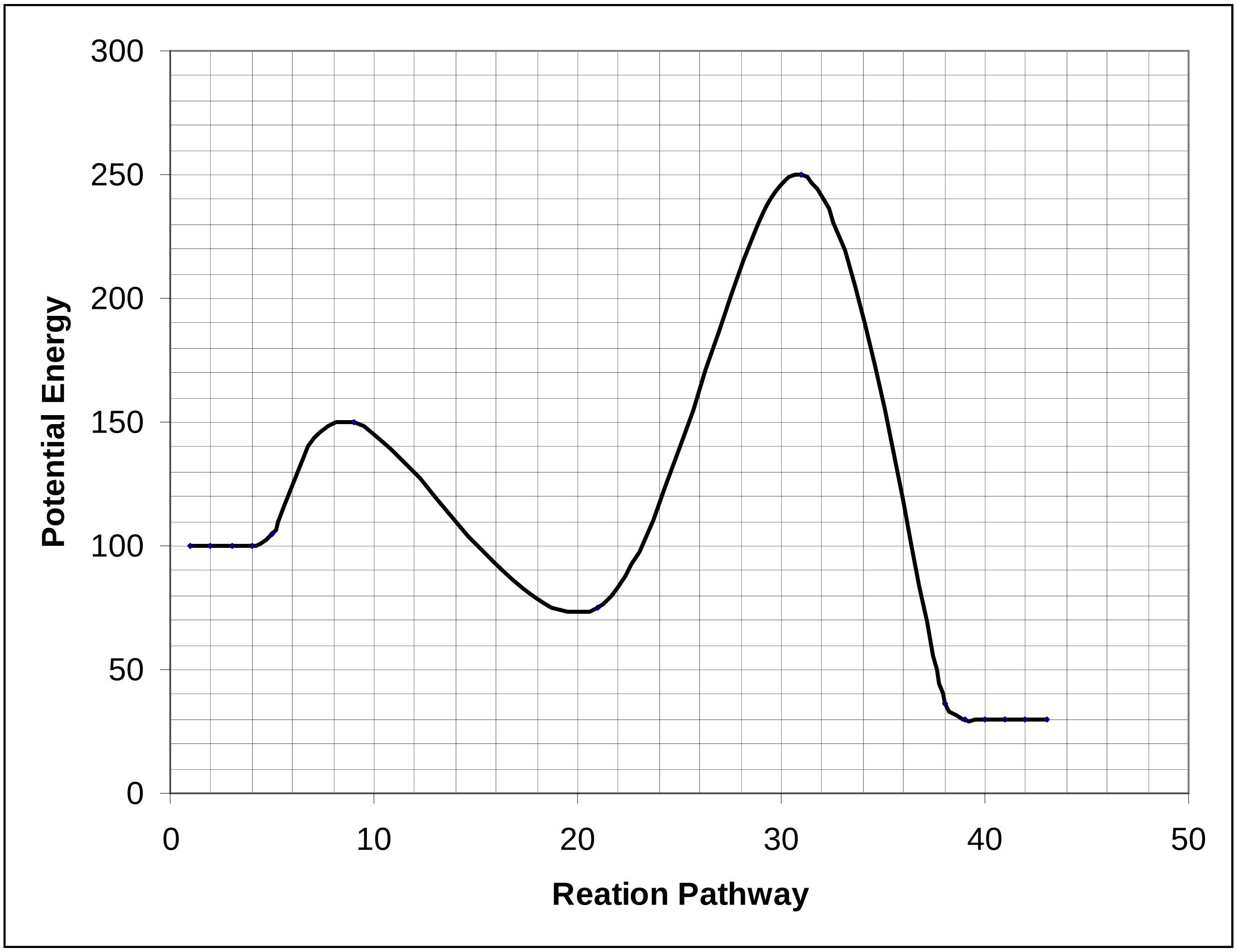
   a. Draw a potential energy curve for the reaction, clearly labeling the following:

      - Indicate a scale on the y-axis with possible values. You do <u>not</u> need to make your graph to scale.
      - Reactants (R), Products (P)
      - Activated Complex (AC)
      - ΔH
      - E_a for the forward reaction

   b. What is the value of E_a for the reverse reaction? **E_a (reverse) = 20 kJ**



9. Consider the following potential energy curve for a two step reaction:



a. Is the overall reaction endothermic or exothermic? **1**

Exothermic

b. What is ΔH for the overall reaction? **1**

- 70 kJ

c. What is the activation energy for the rate-determining step for this reaction? **1**

180 kJ