Rate of chemical reactions

chemical reactions with reference to collision theory, including qualitative interpretation of Maxwell-Boltzmann distribution curves

1. The collision theory of reactions explains why some collisions result in reactions and others do not. Complete the following statement. "According to collision theory, for a reaction to occur, the reactant particles must: " (p175)

2. How does the activation energy affect the rate of a reaction? Use this information to explain the instability of nitroglycerine. (p176, 177)

3. How does the orientation of colliding molecules affect the rate of reaction? Explain your answer by referring to the reaction between hydrogen and iodine. (p177)

4. It can be said that increasing the rate of reaction by increasing the reaction temperature is the result of a two-pronged attack. Explain. (p181)

5. Draw the Maxwell-Boltzmann distribution curves for a reaction run at 0°C, 1000°C, and 2000°C. Explain why the area under the curves remain the same, but the peak and distribution of the curve's changes. (p182)

the comparison of exothermic and endothermic reactions including their enthalpy changes and representations in energy profile diagrams

Exothermic reaction	Endothermic reaction

factors affecting the rate of a chemical reaction including temperature, surface area concentration of solutions, gas pressures and presence of a catalyst

6. Tick whether the following factors increase the rate of reaction by increasing the i) and/or ii) (p179-182)

	temperature	surface Area	concentration	pressure	catalyst
i) frequency of collisions					
ii) proportion of collisions with E > Ea					

the role of catalysts in changing the rate of chemical reactions with reference to alternative reaction pathways and their representation in energy profile diagrams

7. Explain how catalysts increase the rate of a reaction by referring to an energy profile diagram. (p185)

Extent of chemical reactions

the distinction between reversible and irreversible reactions, and between rate and extent of a reaction

8. Explain how one reaction may take only a few seconds and yet the final mixture is mainly reactants, while another reaction may take several days, but the final mixture is mainly products.

homogenous equilibria involving aqueous solutions or gases with reference to collision theory and representation by balanced chemical or thermochemical equations (including states) and by concentration-time graphs.

9. Draw a representation of a concentration-time graph for the decomposition of gaseous NH_3 to nitrogen and hydrogen gas in a closed system. (p198)

calculations involving equilibrium expressions and equilibrium constants (Kc only) for a closed homogeneous equilibrium system including dependence of value of equilibrium constant, and its units, on the equation used to represent the reaction and, on the temperature

10. 6.4 mol of N_2 and 8.5 mol of H_2 are mixed in a 6.0 L vessel. When equilibrium was reached, it was found that 0.5 mol of NH_3 had been formed. Calculate the equilibrium constant. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ Kc = ?

11. Summarise the effect of temperature on the equilibrium constant by stating whether the equilibrium constant will increase or decrease for an exothermic or an endothermic reaction.

	temperature	Kc (increase or decrease)
Exothermic reaction	Increases	
Endothermic reaction	Increases	

12. What is the relationship between the equilibrium constants for the reactions a. and b?

a. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $K_1 = ?$

b. $2N_2(g) + 6H_2(g) \rightleftharpoons 4NH_3(g)$ $K_2 = ?$

Extent of reactions cont.

Le Chatelier's principle: identification of factors that favour the yield of a chemical reaction, representation of equilibrium system changes using concentration-time graphs and applications, including competing equilibria involved in the occurrence and treatment of carbon monoxide poisoning resulting from incomplete combustion of fuels.

13. Identify the factors that would provide the greatest yield for the following chemical reaction;

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ $\Delta H = -180$ kJ mol⁻¹   (p216)

14. Use Le Chatelier's principle to help explain the change in the reaction in Q13 if;

i) oxygen was injected into the system, ii) SO_3 (Sulphur trioxide) was removed, iii) the pressure was decreased

iv) the temperature was increased (p217, 218)

Draw the concentration-time graphs for each change.

15. A syringe contained an equilibrium mixture of the colourless dinitrogen tetraoxide dissociating into the brown nitrogen dioxide can be represented by the following equation: $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ $\Delta H = +54.4$ kJ.mol⁻¹

A timer was set for the reaction. After 5 minutes, the volume of the syringe was halved instantaneously and held at this new volume. A constant temperature was maintained.

a. Draw a rate time graph to represent the change in the rate of forward and reverse reactions.

b. Use collision theory to explain why the rate of formation of nitrogen dioxide;

ii) is constant between 2 to 4 minutes.

iii) increased sharply at 5 minutes before slowly decreasing with time (p217)

c. When the volume was halved, the colour instantly became darker brown. Describe the colour of the mixture once the equilibrium is re-established. Explain your answer. (p217)

16. Carbon monoxide concentrations as low as 200 ppm can have lethal consequences. Use equilibria given below to help explain why carbon monoxide disrupts the equilibrium reaction between haemoglobin and oxygen. (p219)

haemoglobin + oxygen $\rightleftharpoons$ oxyhaemoglobin K_1

haemoglobin + carbon monoxide $\rightleftharpoons$ carboxyhaemoglobin K_2 where $K_2 > K_1$

Rechargeable batteries

the operation of rechargeable batteries (secondary cells) with reference to discharging as a galvanic cell and recharging as an electrolytic cell, including the redox principles (redox reactions and polarity of electrodes) and the factors affecting battery life with reference to components and temperature

22. The vanadium flow battery are large stationary batteries that are used to store electricity generated for use during peak times. During the discharge process, VO_2^+ is reduced to VO^{2+} and V^{2+} is oxidised to V^{3+}

The standard reduction equations for these reactions are shown in Equation 1 and 2.

Equation 1: $VO_2^+{}_{(aq)} + 2H^+ + e- \rightarrow VO^{2+}(aq) + H_2O$ $E_o = 0.99$ V

Equation 2: $V^{3+}{}_{(aq)} + e- \rightarrow V^{2+}{}_{(aq)}$ $E_o = -0.26$ V

a. State the cell voltage produced by the vanadium flow battery.

b. Write the half-equations occurring at the anode and the cathode and give the polarity of the electrodes during **recharge**.

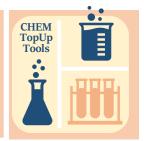| electrodes	Half-equations		polarity
anode			
cathode			

c. A membrane is used to separate the two half cells. Explain why products and reactants transferring across the membrane would lead to losses in battery capacity.

Production of chemicals by electrolysis

electrolysis of molten liquids and aqueous solutions using different electrodes

17. Explain why molten sodium chloride must be used as the electrolyte rather than aqueous sodium chloride to produce sodium metal. (p241)

18. An electrolytic cell with an aqueous solution of copper sulphate as the electrolyte, along with a solid copper anode was used to coat metal objects with copper. Draw a diagram of the cell, labelling the anode, cathode, the polarity of the cell and the direction of electron flow. Identify at which electrode oxidation and reduction occurs and give the oxidation and reduction half-equations and the overall reaction. (p240)

the general operating principles of commercial electrolytic cells, including basic structural features and selection of suitable electrolyte (molten or aqueous) and electrode (inert or reactive) materials to obtain desired products

the use of the electrochemical series to explain or predict the products of an electrolysis, including identification of species that are preferentially discharged, balanced half-equations, a balanced ionic equation for the overall cell reaction, and states

19. Use the electrochemical series to predict the products of the electrolysis of 1 M Lead(II) sulphate with copper electrodes at 25°C. Draw a diagram of the cell. Label the anode, cathode, give the polarity of the electrodes, identify where oxidation and reduction occur, give the half equations and the overall equation. (p243)

the comparison of an electrolytic cell with a galvanic cell with reference to the energy transformations involved and basic structural features and processes

20. Complete the table to compare electrolytic cells with galvanic cells.

	electrolytic cell	galvanic cell
process		
design features		
energy transformation		

the application of stoichiometry and Faraday's Laws to determine amounts of product, current or time for a particular electrolytic process

21. A current of 2.5 A is passed for 50 minutes through an electrolytic cell which contains a pair of copper electrodes. The same amount of current is passed through an electrolytic cell which contains a pair of platinum electrodes for the same amount of time. Both cells contain 1.0 M of copper chloride.
a. Draw labelled diagrams to represent each cell.

b. 7500 Coulombs of charge was passed through each cell after 50 minutes. What would be the effect on the amount of charge if the current was increased from 2.5 amps to 3.0 amps?

c. Calculate the amount of electrons, in mole, passing through the cell when 2.5 A of current was used.

d. Calculate the theoretical mass of copper that could be deposited on the cathode of the cell with copper electrodes.

e. The mass of copper deposited on the cathode in the cell with platinum electrodes differed from the cell with the copper electrodes. Describe this difference and explain why this was the case. Assume that there was no loss of copper due to precipitation on the base of the cell.

Adele Hudson, Feb 2020