Grade 12 Chemistry Model Paper 1

MODEL PAPER

Full marks 75 · 3 hours

Name _____ Class _____ Roll no. ____ Date _____ Marks _____ / 75

Answer every question; where a question has an OR question, answer either one. Time: 3 hours.

A practice paper by Science Playground, made to CDC's Specification Grid 2078, Grade 12 Chemistry (Che. 302); not an official CDC or NEB paper. Mark it yourself online: the QR code below opens the paper with its answers.

A full practice run of the NEB Grade 12 Chemistry paper (Che. 302): 75 marks in 3 hours, 12 questions in three groups. Group A is one question of 11 multiple-choice items, about 25 minutes; groups B and C have short- and long-answer questions of two to four parts, with each part's marks shown. Questions 2 and 6 in group B and Questions 10 and 12 in group C each have an OR question: answer either the question or its OR question, every part from the same one, and mark only the one you answered. Write on paper first, then tap your choice in group A and open each other part's answer to give yourself the marks its scheme allows. Where needed, take the atomic masses H = 1, C = 12, N = 14, O = 16, Na = 23, Ca = 40, K = 39, Mn = 55, Cr = 52, $R = 8.314\ \text{J K}^{-1}\ \text{mol}^{-1}$, $F = 96{,}485\ \text{C mol}^{-1}$ and $\frac{2.303RT}{F} = 0.0592\ \text{V}$ at 25 °C.

Group A Multiple choice — 11 marks

Question 1 — 11 × 1 = 11

Choose the correct option for each of the following questions.

a. Potassium dichromate (M = 294) is used as an oxidizing agent in acidic medium, where $Cr_2O_7^{2-}$ is reduced to Cr^{3+}. What is its equivalent weight in this reaction?

(i) 294 (ii) 147 (iii) 98 (iv) 49

b. What is the pH of a 0.005 M solution of barium hydroxide, $Ba(OH)_2$, at 25 °C? (Take it as fully ionized.)

(i) 2.0 (ii) 11.7 (iii) 12.0 (iv) 13.0

c. The half-life of a first-order reaction is 20 minutes. What percentage of the reactant is left after one hour?

(i) 0% (ii) 12.5% (iii) 25% (iv) 33.3%

d. In a Daniell cell, $Zn \mid Zn^{2+} \parallel Cu^{2+} \mid Cu$, which of these happens while the cell gives a current?

(i) Zinc is oxidized at the anode, and the zinc rod slowly gets thinner.
(ii) Copper is oxidized at the anode, and blue color deepens.
(iii) Electrons flow through the wire from copper to zinc.
(iv) Zinc ions are reduced and deposited on the zinc rod.

e. Which of these ions is colorless in aqueous solution?

(i) Cu^{2+} (ii) Fe^{3+}
(iii) Ti^{3+} (iv) Zn^{2+}

f. In the cyanide process for silver, zinc dust is added to the solution of sodium dicyanidoargentate(I), $Na[Ag(CN)_2]$. Why?

(i) Zinc makes the solution alkaline so that silver hydroxide is precipitated.
(ii) Zinc is more electropositive than silver, so it displaces silver from the complex.
(iii) Zinc oxidizes the silver ions to silver oxide.
(iv) Zinc forms an alloy with silver that is easier to melt.

g. What is formed when a mixture of chlorobenzene and chloromethane is heated with sodium in dry ether?

(i) biphenyl only (ii) toluene (methylbenzene)
(iii) benzene (iv) chlorotoluene

h. In Williamson's synthesis of an ether, a tertiary haloalkane is not used with sodium ethoxide. Why?

(i) It does not react with sodium ethoxide at all.

(ii) It gives an ester instead of an ether.

(iii) The strongly basic alkoxide removes a hydrogen and gives an alkene by elimination.

(iv) It gives a symmetrical ether only.

i. The fishing net of a fisherman at Phewa Lake is made of nylon-6,6. Which statement about this polymer is correct?

(i) It is an addition polymer of ethene.

(ii) It is a condensation polymer of hexane-1,6-diamine and hexanedioic acid (adipic acid), formed with loss of water.

(iii) It is a natural polymer made from cellulose.

(iv) It is a thermosetting polymer of phenol and methanal.

j. Rosin and alum are added to the pulp when writing paper is made. What is their main purpose?

(i) to make the paper whiter

(ii) to remove the lignin from the fibers

(iii) to size the paper, so that ink does not spread or soak through it

(iv) to make the fibers longer

k. Charcoal from an old hearth near Lo Manthang shows 25% of the carbon-14 activity of living wood, so the laboratory reports an age of about 11,460 years (two half-lives of 5,730 years). Later it is found that roots of living plants had grown into the charcoal before it was dug up. What does this mean for the age?

(i) The charcoal is really older than 11,460 years.

(ii) The charcoal is really younger than 11,460 years.

(iii) The age stands, because roots contain no carbon-14.

(iv) The age stands, because roots cannot change the half-life of carbon-14.

Group B Short answers, each on one content area — 40 marks

Question 2 — 5 marks

A lime kiln near the cement plant in Udayapur turns limestone into quicklime:

$$\mathrm{CaCO_3\,(s) \longrightarrow CaO\,(s) + CO_2\,(g)}$$

Standard values at 25 °C:

Substance	ΔH_f° (kJ mol⁻¹)	S° (J K⁻¹ mol⁻¹)
$CaCO_3$(s)	−1207.6	91.7
CaO(s)	−634.9	38.1
CO_2(g)	−393.5	213.8

a. State the second law of thermodynamics in terms of entropy. **[1]**

b. Calculate the standard enthalpy change of the reaction. **[2]**

c. Find ΔS° and ΔG° at 25 °C, and use them to explain why limestone has to be heated strongly before it breaks up. Above about what temperature does the reaction become spontaneous? **[2]**

OR

Hydrogen peroxide decomposes by first-order kinetics on a manganese(IV) oxide catalyst:

$$\mathrm{2\,H_2O_2\,(aq) \longrightarrow 2\,H_2O\,(l) + O_2\,(g)}$$

In an experiment, its concentration falls from 0.80 mol/L to 0.20 mol/L in 30 minutes.

a. Define the order of a reaction. **[1]**

b. Calculate the rate constant and the half-life of the reaction. **[2]**

c. When the same experiment is repeated at 35 °C instead of 25 °C, the rate constant doubles. Calculate the activation energy of the reaction, and explain how a 10 °C rise, which raises the average kinetic energy of the molecules by only about 3%, can double the rate. **[2]**

Question 3 — 5 marks

Pragya prepares a standard solution of oxalic acid in her school laboratory in Pokhara by dissolving 0.63 g of oxalic acid crystals, $H_2C_2O_4 \cdot 2H_2O$ (M = 126), in water and making it up to 100 mL. She then titrates 20.0 mL of it, warmed to about 60 °C with dilute sulphuric acid, against a potassium permanganate solution from a burette. The first lasting pale pink color appears when 25.0 mL has been added.

a. What is a standard solution? **[1]**

b. Calculate the normality of the oxalic acid solution. **[2]**

c. Find the normality of the permanganate solution and its strength in grams per liter. Her partner says dilute hydrochloric acid would have done as well as sulphuric acid. Had they used it, would the normality of the permanganate found have been too high, too low or the same? Give a reason. **[2]**

Question 4 — 5 marks

Dolma has two iron(III) complexes in her laboratory: the pale violet hexaaquairon(III) ion, $[Fe(H_2O)_6]^{3+}$, and the red hexacyanidoferrate(III) ion, $[Fe(CN)_6]^{3-}$.

a. Define a ligand and the coordination number of a complex, using $[Fe(CN)_6]^{3-}$ as the example. **[2]**

b. Why are most complexes of transition metal ions colored? **[1]**

c. Fe^{3+} is $3d^5$. Using crystal field theory, show how the five d electrons are arranged in each complex, given that H_2O is a weak-field and CN^- a strong-field ligand, and predict the number of unpaired electrons in each. **[2]**

Question 5 — 5 marks

The corrugated roofs (*jasta*) of many village houses are galvanized iron. Galvanizing uses about half of all the zinc the world produces.

a. Name the chief ore of zinc and write the equation for its roasting. **[2]**

b. Write the equation for the reduction of the roasted ore to zinc, with its condition. **[1]**

c. A nail scratches a galvanized roof down to the iron. Explain why the iron at the scratch still does not rust for a long time. ($E^\circ_{Zn^{2+}/Zn} = -0.76$ V, $E^\circ_{Fe^{2+}/Fe} = -0.45$ V) **[2]**

Question 6 — 5 marks

Two isomers of C_4H_9Br are on a shelf: 1-bromobutane, $CH_3CH_2CH_2CH_2Br$, and $(CH_3)_3CBr$.

a. Write the IUPAC name of $(CH_3)_3CBr$ and say whether it is a primary, secondary or tertiary haloalkane. **[1]**

b. 1-Bromobutane is boiled with aqueous potassium hydroxide, and the product is then heated with excess acidified potassium dichromate. Write the equations for the two steps and name the products. **[2]**

c. $(CH_3)_3CBr$ is hydrolyzed by water much faster than 1-bromobutane, and doubling the concentration of OH^- does not change its rate. Explain both facts. **[2]**

OR

Anisole, a sweet-smelling liquid used in perfumes, is an aromatic ether.

a. Write the IUPAC name and the formula of anisole. **[1]**

b. Write the equation for preparing anisole by Williamson's synthesis, and the equation for its bromination in ethanoic acid, naming the main product. **[2]**

c. Another aryl alkyl ether, Z, $C_8H_{10}O$, is heated with concentrated hydroiodic acid. One product gives a violet color with neutral iron(III) chloride; the other is an iodoalkane with two carbon atoms. Identify Z, write the equation, and explain why the iodine joins the alkyl group and not the ring. **[2]**

Question 7 — 5 marks

Bishal tests a sample of phenol and compares it with nitrobenzene.

a. What is seen when a few drops of neutral iron(III) chloride solution are added to an aqueous solution of phenol? **[1]**

b. Phenol is a stronger acid than ethanol. Explain why. **[2]**

c. Phenol is nitrated by dilute nitric acid at room temperature, giving 2-nitrophenol and 4-nitrophenol. Nitrobenzene needs fuming nitric acid and concentrated sulphuric acid at about 100 °C, and gives 1,3-dinitrobenzene. Explain the difference in conditions and in the positions taken. **[2]**

Question 8 — 5 marks

Grignard reagents and amines are both used to build new carbon chains and nitrogen compounds in the laboratory.

a. What is a Grignard reagent? Give its general formula. **[1]**

b. Write the equations for the reaction of methylmagnesium bromide with (i) methanal and (ii) carbon dioxide, each followed by hydrolysis with dilute acid, and name the products. **[2]**

c. An amine Y, C_2H_7N, gives no foul smell when warmed with chloroform and alcoholic potassium hydroxide. Identify Y, giving your reason, and write the equation for the reaction its isomer gives in the same test. **[2]**

Question 9 — 5 marks

Abinash is building a house in Ghorahi with cement from a Nepali plant.

a. What is cement clinker? **[1]**

b. Explain how cement sets and hardens after it is mixed with water. **[2]**

c. In the kiln, limestone loses carbon dioxide: $CaCO_3 \longrightarrow CaO + CO_2$. How much calcium oxide can one tonne of pure limestone give? **[1]**

d. The mason tells Abinash to splash water on the new roof slab every day for two weeks. Give the chemical reason. **[1]**

Group C Long answers, each on one content area — 24 marks

Question 10 — 8 marks

A buffer is made by mixing ethanoic acid and sodium ethanoate so that the solution is 0.10 M in CH_3COOH **and 0.15 M in** CH_3COONa**.** $K_a(CH_3COOH) = 1.75 \times 10^{-5}$ **at 25 °C.**

a. Explain, with equations, how this solution resists a change in pH when a little acid or a little base is added to it. **[3]**

b. Calculate the pH of the buffer. **[3]**

c. $K_{sp}(\text{AgCl}) = 1.8 \times 10^{-10}$. How many times less soluble is silver chloride in 0.010 M sodium chloride solution than in pure water? Show your working. **[2]**

OR

Nischal sets up a Daniell cell, $\text{Zn} \mid \text{Zn}^{2+}(0.10\,\text{M}) \parallel \text{Cu}^{2+}(0.0010\,\text{M}) \mid \text{Cu}$**, at 25 °C.** $E^\circ_{\text{Zn}^{2+}/\text{Zn}} = -0.76\,\text{V}$ **and** $E^\circ_{\text{Cu}^{2+}/\text{Cu}} = +0.34\,\text{V}$**.**

a. Describe the standard hydrogen electrode, and explain how it is used to find the standard electrode potential of zinc. **[3]**

b. Calculate the emf of Nischal's cell. **[3]**

c. Calculate the standard free energy change of the cell reaction and the free energy change in Nischal's cell as it is set up. Explain why the two differ. **[2]**

Question 11 — 8 marks

Samir is given two aldehydes in his laboratory: benzaldehyde, which smells of bitter almonds, and ethanal.

a. Benzaldehyde undergoes the Cannizzaro reaction with concentrated sodium hydroxide, but ethanal does not. Explain why, and write the equation for benzaldehyde. **[3]**

b. Write the equation for the reaction of ethanal with dilute sodium hydroxide, and name the product. **[2]**

c. A compound P, $\text{C}_4\text{H}_8\text{O}$, gives an orange-yellow precipitate with 2,4-dinitrophenylhydrazine and a yellow precipitate when warmed with iodine and sodium hydroxide, but gives no silver mirror with Tollens' reagent. Identify P, write the equation for the yellow precipitate, and explain why P gives no silver mirror. **[3]**

Question 12 — 8 marks

Sana compares ethanoic acid (b.p. 118 °C) with propan-1-ol (b.p. 97 °C), whose molar mass is the same, 60 g mol^{-1}.

a. Why does ethanoic acid boil at a higher temperature than propan-1-ol? **[2]**

b. Convert ethanoic acid into methanamine, writing the equation for each step with its condition. **[3]**

c. Two unlabelled bottles, A and B, hold 0.10 M solutions of methanoic acid and of ethanoic acid. Solution A has pH 2.4 and solution B pH 2.9, and only one of them gives a silver mirror with Tollens' reagent. Say which acid is in each bottle, explaining both the pH values and which one gives the mirror, and write the equation for the mirror. **[3]**

OR

Aniline, $\text{C}_6\text{H}_5\text{NH}_2$**, is the starting material for many dyes and medicines.**

a. Aniline is a weaker base than ammonia. Explain why. **[2]**

b. How is aniline turned into a scarlet dye with naphthalen-2-ol (2-naphthol)? Write the equations and the conditions. **[3]**

c. Aniline and bromine water give 2,4,6-tribromoaniline at once. How would you make 4-bromoaniline instead? Give the steps and the reason. **[3]**