Grade 11 Chemistry Model Paper 3

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 2077, Grade 11 Chemistry (Che. 301); 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 NEB's Grade 11 Chemistry paper (Che. 301): 75 marks in 3 hours. Question 1 is group A, 11 multiple-choice items; questions 2 to 9 are group B and questions 10 to 12 group C, each of two to four parts with the marks of each part. Questions 2 and 4 in group B and Question 11 in group C have an OR question: answer either one. Take $N\mathrm{A} = 6.022 \times 10^{23}$ per mol, the molar volume of a gas at STP as 22.4 L and $R = 0.0821$ L atm/(mol K); atomic masses are given where a question needs them. Write your answers on paper as in the exam hall, then tap your choice in group A, open each other part's answer and give yourself the marks its scheme allows.

Group A Multiple choice — 11 marks

Question 1 — 11 × 1 = 11

Choose the correct option for each of the following questions.

a. What is the formula of aluminium sulphate?

(i) $AlSO_4$ (ii) $Al_3(SO_4)_2$ (iii) $Al(SO_4)_3$ (iv) $Al_2(SO_4)_3$

b. Why does water boil below 100 °C at Everest Base Camp?

(i) The air pressure there is lower.

(ii) The thin air there contains less oxygen to heat the water.

(iii) Snow-melt water there contains fewer dissolved salts.

(iv) The cold air takes heat away from the pan faster.

c. Which of these molecules has polar bonds but a zero dipole moment?

(i) H_2O (ii) CO_2 (iii) NH_3 (iv) CH_3Cl

d. For the reaction $N_2(g) + 3\,H_2(g) \rightleftharpoons 2\,NH_3(g)$, how are K_p and K_c related?

(i) $K_p = K_c$

(ii) $K_p = K_c(RT)^2$

(iii) $K_p = K_c(RT)^{-2}$

(iv) $K_p = K_c(RT)^{-4}$

e. 4 g of hydrogen and 16 g of oxygen are exploded together: $2\,H_2 + O_2 \longrightarrow 2\,H_2O$. What mass of water forms? (H = 1, O = 16)

(i) 9 g (ii) 18 g (iii) 20 g (iv) 36 g

f. Why does the sodium–potassium pump need energy from ATP?

(i) Sodium and potassium ions are too large to pass through the membrane.

(ii) It turns sodium ions into potassium ions.

(iii) It carries both ions down their concentration gradients.

(iv) It carries Na^+ out of the cell and K^+ in, both against their concentration gradients.

g. Of the alkali metal carbonates, only lithium carbonate breaks up on strong heating, into lithium oxide and carbon dioxide; sodium and potassium carbonates don't. Which explanation fits?

(i) Li^+ is the smallest alkali metal ion, so it polarizes the carbonate ion most.

(ii) Lithium is the most reactive alkali metal, so its compounds are the least stable.

(iii) Lithium has the lowest ionization energy of the alkali metals.

(iv) Lithium carbonate dissolves in water more than the others.

h. Which greenhouse gas is given off by the chemical reaction itself when cement is made from limestone?

(i) Methane (ii) Nitrous oxide (iii) Sulphur dioxide (iv) Carbon dioxide

i. In Ostwald's process, the hot gas from the converter is cooled before its nitric oxide is oxidized to nitrogen dioxide. Why?

(i) Because the reaction $2NO + O_2 \rightarrow 2NO_2$ goes faster at lower temperatures

(ii) To liquefy the nitric oxide

(iii) To stop the platinum–rhodium gauze from melting

(iv) To remove the unreacted ammonia as a liquid

j. When brine is electrolyzed in a diaphragm cell, hydrogen, not sodium, is given off at the cathode. Why?

(i) Sodium ions move to the anode.

(ii) Water is reduced far more easily than Na^+.

(iii) Sodium forms first but turns back into sodium chloride in the brine.

(iv) The diaphragm stops sodium ions reaching the cathode.

k. In Ostwald's process the overall change is $NH_3 + 2\,O_2 \longrightarrow HNO_3 + H_2O$. What is the greatest mass of nitric acid that 3.4 tonnes of ammonia can give? (N = 14, H = 1, O = 16)

(i) 3.4 tonnes (ii) 6.3 tonnes (iii) 12.6 tonnes (iv) 25.2 tonnes

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

Question 2 — 5 marks

The third shell of an atom can hold up to 18 electrons, yet the third period of the periodic table has only eight elements, sodium to argon.

a. Name the four quantum numbers and state Pauli's exclusion principle. **[2]**

b. Write a set of the four quantum numbers for the outermost (19th) electron of potassium (Z = 19). **[1]**

c. Explain why the third period has only eight elements although the third shell can hold 18 electrons. **[2]**

OR

Lhakpa, a mountain guide, explains to trekkers that the air at Everest's summit has the same share of oxygen as at sea level, about 21% by moles, yet climbers carry oxygen bottles.

a. State Dalton's law of partial pressures. What is the partial pressure of a gas in a mixture? **[2]**

b. Oxygen is collected over water at 25 °C when the atmospheric pressure is 760 mmHg. The vapor pressure of water at 25 °C is 23.8 mmHg. What is the partial pressure of the dry oxygen? **[1]**

c. At Everest's summit the total pressure is about a third of an atmosphere. Find the partial pressure of oxygen there and explain why climbers carry oxygen although the air is still 21% oxygen. **[2]**

Question 3 — 5 marks

Aayush stirs a blue copper(II) sulphate solution with an iron spoon. The spoon is soon coated red-brown, and the blue color slowly fades.

a. Define an oxidizing agent in terms of electrons. **[1]**

b. Balance the following equation in acidic solution by the ion-electron method: **[2]**

$$Cr_2O_7^{2-} + I^- \longrightarrow Cr^{3+} + I_2$$

c. Explain Aayush's observations with an equation, saying which substance is oxidized. Could silver nitrate solution be stored safely in a copper vessel? Explain. **[2]**

Question 4 — 5 marks

Phosphorus pentachloride breaks up on heating: $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$**. 1.0 mol of PCl_5 is heated in a closed 2.0 L flask, and at equilibrium the flask contains 0.40 mol of Cl_2.**

a. State the law of mass action. What does a very large value of K_c tell you about a reaction? **[2]**

b. Calculate K_c for the reaction at this temperature. **[2]**

c. Some more chlorine is pumped into the flask at the same temperature, and the mixture settles to a new equilibrium. Using the expression for K_c, explain why the amount of PCl_5 must now be greater than before. **[1]**

OR

Methane, CH_4, phosphorus pentachloride, PCl_5, and sulphur hexafluoride, SF_6, all have only bond pairs round their central atoms.

a. Explain the sp^3 hybridization of carbon in methane, and the shape and bond angle it gives. **[2]**

b. Give the hybridization of phosphorus in PCl_5, and the shapes and bond angles of PCl_5 and SF_6. **[2]**

c. Sulphur forms SF_6, but oxygen, in the same group, forms no OF_6. Why? **[1]**

Question 5 — 5 marks

Sulphuric acid is used in so many industries that it is called the king of chemicals.

a. Why is sulphuric acid called the king of chemicals? **[1]**

b. A few drops of concentrated sulphuric acid on sugar turn it into a black, swelling mass. Which property of the acid does this show? Explain. **[1]**

c. Write the balanced equation for the reaction of copper with hot, concentrated sulphuric acid. **[1]**

d. Concentrated sulphuric acid is used in the laboratory to dry chlorine, sulphur dioxide and hydrogen chloride, but never to dry ammonia or hydrogen sulphide. Explain why it can't dry each of those two gases, with an equation for each. **[2]**

Question 6 — 5 marks

Samiksha reads that there is no known safe level of lead in a child's blood, and that mercury is just as feared.

a. Name two sources of lead in daily life and two harmful effects of lead on children. **[2]**

b. A child in a family that breaks up old car batteries at home is found to be anemic and has trouble learning. Using what lead does to enzymes and to the body's metal ions, explain how lead could cause (i) the anemia and (ii) the harm to the brain and nerves. **[2]**

c. A river holds about 0.0001 mg of mercury per litre, but a large fish caught in it holds about 0.5 mg per kilogram, some 5000 times as much. A villager says the fish must be safe to eat, since the river water is safe to drink. Explain why she is wrong. **[1]**

Question 7 — 5 marks

Benzene is the parent of the aromatic compounds, and the Friedel–Crafts reactions join new carbon groups to its ring.

a. State Hückel's rule of aromaticity. **[1]**

b. Write the equations for (i) the Friedel–Crafts alkylation of benzene with chloroethane and (ii) its Friedel–Crafts acylation with ethanoyl chloride, naming the catalyst and the organic product of each. **[2]**

c. Cyclopentadiene, C_5H_6, is not aromatic: its CH_2 carbon is sp^3. Use Hückel's rule to decide whether (i) the cyclopentadienyl anion, $C_5H_5^-$, formed when that CH_2 loses an H^+, which leaves the carbon sp^2 with its lone pair in a p orbital and the ring flat, and (ii) cyclooctatetraene, C_8H_8, a ring of eight carbons with four C=C bonds, bent into the shape of a tub, is aromatic. **[2]**

Question 8 — 5 marks

Kritika has an unknown alkene. To find where its double bond is, she treats it with ozone and then with zinc and water, and identifies the products.

a. What is ozonolysis? Give the reagents and conditions used. **[2]**

b. Name the products of ozonolysis of (i) propene and (ii) 2-methylbut-2-ene, $(CH_3)_2C{=}CH{-}CH_3$. **[2]**

c. Kritika's alkene, C_6H_{12}, gives only propanone on ozonolysis. Write its structure and IUPAC name. **[1]**

Question 9 — 5 marks

On the night of 2–3 December 1984, about 40 tonnes of a poisonous gas, methyl isocyanate, escaped from a pesticide plant in Bhopal, India, into the sleeping town around it, killing thousands of people.

a. Name any two safety measures used in a chemical plant. **[1]**

b. Why must chemical plants be inspected and maintained regularly? Give two things that can go wrong if they are not. **[2]**

c. A company plans a plant near a town in Nepal that will keep 50 tonnes of a very poisonous liquid in one large tank, 100 m from the nearest houses. Using the Bhopal disaster, point out two weaknesses in this plan, other than inspection and maintenance, and suggest how to correct each. **[2]**

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

Question 10 — 8 marks

Magnesium (Z = 12) and sulphur (Z = 16) are in the third period. A sulphur atom is smaller than a magnesium atom, and its first ionization energy is higher.

a. What is the shielding (screening) effect? **[1]**

b. Use Slater's rules to find the effective nuclear charge felt by the outermost electron of magnesium. **[2]**

c. Use Slater's rules to find the effective nuclear charge felt by the outermost (3p) electron of sulphur. **[2]**

d. Use your answers to explain why (i) a sulphur atom is smaller than a magnesium atom, (ii) sulphur's first ionization energy is higher, and (iii) magnesium forms Mg^{2+} ions while sulphur forms S^{2-} ions. **[3]**

Question 11 — 8 marks

Bipana's teacher shows the class a piece of sodium kept under kerosene, then drops a small piece into a trough of water.

a. Why are the alkali metals kept under kerosene? Explain why their reaction with water becomes more violent from lithium to potassium. **[3]**

b. Sodium salts color a flame golden yellow. Why do alkali metals color a flame? **[1]**

c. Write balanced equations for the reaction of sodium (i) with water and (ii) with oxygen when heated. **[2]**

d. A bottle of sodium hydroxide pellets left open becomes wet and then covered with a white crust. Explain both changes, with an equation. **[2]**

OR

Nitric acid is a strong acid and also an oxidizing agent. The brown ring test, which detects nitrate ions, depends on its oxidizing nature.

a. Describe the brown ring test for a nitrate, and explain what the brown ring is and how it forms. **[3]**

b. Why is nitric acid stored in dark brown bottles? **[1]**

c. Write balanced equations for the action of copper on (i) concentrated and (ii) dilute nitric acid. **[2]**

d. In both of your equations each copper atom loses two electrons. Use oxidation numbers to work out what fraction of the nitric acid is reduced in each reaction, and explain why the dilute acid needs fewer nitric acid molecules to be reduced for each copper atom. **[2]**

Question 12 — 8 marks

Carbon forms more compounds than all the other elements together. Among them, but-2-ene exists as two different compounds with the same structural formula.

a. What is geometrical isomerism? Explain it with but-2-ene, and state the conditions for a compound to show it. **[3]**

b. Which of these show geometrical isomerism: propene, 2-methylpropene, pent-2-ene? Give reasons. **[2]**

c. When decane, $C_{10}H_{22}$, is cracked, one product is octane, C_8H_{18}. Deduce the formula of the other product and the family it belongs to. Explain why cracking an alkane always gives at least one alkene. **[2]**

d. Silicon has four valence electrons like carbon, yet in nature it is never found in chains of silicon atoms, only joined to oxygen, in silica and the silicates. Use these bond energies (kJ/mol) to explain why: C–C 346, C–O 358, Si–Si 226, Si–O 452. **[1]**