Grade 11 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 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 one atomic mass unit (amu)?

(i) The mass of one hydrogen atom
(ii) One-twelfth of the mass of one carbon-12 atom
(iii) The mass of one proton and one electron together
(iv) One-sixteenth of the mass of one oxygen-16 atom

b. Which set of quantum numbers is **not** possible for an electron?

(i) $n = 3,\ l = 2,\ m = -2,\ s = +\frac{1}{2}$
(ii) $n = 2,\ l = 1,\ m = 0,\ s = -\frac{1}{2}$
(iii) $n = 1,\ l = 0,\ m = 0,\ s = -\frac{1}{2}$
(iv) $n = 2,\ l = 2,\ m = +1,\ s = +\frac{1}{2}$

c. What is the shape of the ammonia molecule, NH_3?

(i) Trigonal pyramidal (ii) Trigonal planar
(iii) Tetrahedral (iv) T-shaped

d. How many molecules are there in 3.4 g of ammonia? (N = 14, H = 1)

(i) 6.02×10^{22}
(ii) 1.20×10^{23}
(iii) 4.82×10^{23}
(iv) 2.05×10^{24}

e. A gas occupies 600 mL at 27 °C. What volume will it occupy at 127 °C, the pressure staying the same?

(i) 450 mL (ii) 642 mL (iii) 800 mL (iv) 2822 mL

f. Why is nitrogen gas so unreactive at room temperature?

(i) Its triple bond needs a very large energy, 946 kJ/mol, to break.
(ii) Its molecule has no lone pairs of electrons.
(iii) It is a noble gas with a full outer shell.
(iv) It is too light to collide hard with other molecules.

g. Barium ions are poisonous, yet a patient drinks a barium compound before an X-ray of the stomach. Which compound must it be, and why? (The stomach contains dilute hydrochloric acid.)

(i) Barium chloride, because it dissolves and spreads evenly

(ii) Barium carbonate, because it is insoluble in water

(iii) Barium hydroxide, because it neutralizes the stomach acid

(iv) Barium sulphate, because it is almost insoluble, even in the stomach's acid

h. Which of these is **not** one of the four factors of production?

(i) Land (ii) Capital (iii) Market demand (iv) Entrepreneurship

i. In the contact process, sulphur trioxide is absorbed in 98% sulphuric acid and not in water. Why?

(i) With water it reacts so violently that the acid forms as a mist, which is hard to collect.

(ii) Sulphur trioxide does not react with water at all.

(iii) Water would reduce sulphur trioxide back to sulphur dioxide.

(iv) 98% sulphuric acid is cheaper than water.

j. Why does the sodium hydroxide solution that comes out of a diaphragm cell always contain sodium chloride?

(i) The cathode turns some sodium hydroxide back into salt.

(ii) Salt is added to the product to keep it from absorbing carbon dioxide.

(iii) Chlorine at the anode reacts with the sodium hydroxide to give salt.

(iv) The porous diaphragm lets brine, salt and all, seep through to the cathode side.

k. The overall change in the Solvay process is $2\,NaCl + CaCO_3 \longrightarrow Na_2CO_3 + CaCl_2$. What is the greatest mass of sodium carbonate that 117 kg of sodium chloride can give? (Na = 23, Cl = 35.5, C = 12, O = 16)

(i) 53 kg (ii) 106 kg (iii) 117 kg (iv) 212 kg

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

Question 2 — 5 marks

The ions N^{3-}, O^{2-}, F^-, Na^+, Mg^{2+} and Al^{3+} all have the same number of electrons.

a. What are isoelectronic species? How many electrons does each of these ions have, and which noble gas has the same arrangement? **[2]**

b. Arrange the six ions in order of increasing ionic radius. **[1]**

c. A sodium atom (186 pm) is more than twice the size of a fluorine atom (71 pm), yet the Na^+ ion (102 pm) is smaller than the F^- ion (133 pm). Explain why the order is reversed when the atoms become ions. **[2]**

OR

Bohr's model of the hydrogen atom explained the lines of hydrogen's spectrum, and was later replaced by the quantum mechanical model.

a. State any two postulates of Bohr's atomic model. **[2]**

b. The electron of a hydrogen atom falls from the third orbit to the second. To which spectral series does the line belong, and in which region of the spectrum is it? **[1]**

c. Before the neutron was found, Bibisha reads, some scientists thought the nucleus held electrons as well as protons. A nucleus is about 1.0×10^{-14} m across. Use Heisenberg's uncertainty principle to find the least uncertainty in the velocity of an electron confined in a nucleus, and use your answer to judge the idea. ($h = 6.626 \times 10^{-34}$ J s, mass of an electron 9.11×10^{-31} kg, speed of light 3.0×10^8 m/s) **[2]**

Question 3 — 5 marks

Dipesh drops zinc granules into very dilute nitric acid. The zinc dissolves, but no gas comes off. When the solution is later warmed with sodium hydroxide, it gives ammonia. The skeleton equation is:

$$Zn + HNO_3 \longrightarrow Zn(NO_3)_2 + NH_4NO_3 + H_2O$$

a. Define oxidation and reduction in terms of oxidation number. **[1]**

b. Balance the equation by the oxidation number method. **[2]**

c. Name the oxidizing agent and the reducing agent. In your balanced equation, what fraction of the nitric acid molecules is actually reduced? Explain what the others do. **[2]**

Question 4 — 5 marks

Nitrogen dioxide, a brown gas, and dinitrogen tetroxide, colorless, are in equilibrium in a sealed 2.0 L flask at 100 °C:

$$N_2O_4\,(g) \rightleftharpoons 2\,NO_2\,(g)$$

At equilibrium the flask contains 0.040 mol of N_2O_4 and 0.24 mol of NO_2.

a. Chemical equilibrium is said to be dynamic. Explain what this means, using this reaction. **[2]**

b. Write the expression for K_c and calculate its value. **[2]**

c. The flask is squeezed to half its volume at the same temperature. Which way does the equilibrium shift? Give a reason. **[1]**

OR

Ujwal fills a 5.0 L cylinder with 3.2 g of oxygen at 27 °C (O = 16).

a. Explain from the kinetic theory of gases why the gas exerts a pressure on the walls of the cylinder, and why the pressure rises if the cylinder is warmed. **[2]**

b. Calculate the pressure of the oxygen in the cylinder. **[2]**

c. Ujwal also has cylinders of hydrogen and of ammonia. At the same high pressure and temperature, which of the three gases, hydrogen, oxygen or ammonia, would you expect to depart most from $PV = nRT$? Give a reason. **[1]**

Question 5 — 5 marks

Shreya buys a bottle of "20 volume" hydrogen peroxide at a pharmacy in Pokhara to clean a cut. When she pours some on the wound, it froths.

a. What does "20 volume" hydrogen peroxide mean? **[1]**

b. Why does the hydrogen peroxide froth on the wound? **[1]**

c. What volume of oxygen at STP can 5 mL of this solution give? **[1]**

d. Three months later the pharmacist tests Shreya's bottle, which has stood open in a warm, bright room, and finds it is now only "10 volume". Explain how it lost strength, and calculate what fraction of its hydrogen peroxide has decomposed and the volume of oxygen at STP that 100 mL of it has lost. **[2]**

Question 6 — 5 marks

A health worker tests the tube well of Sneha's family in Nawalparasi. The water has 80 µg of arsenic per litre. (The WHO advises at most 10 µg/L in drinking water; Nepal's standard allows 50 µg/L.)

a. What is meant by metal toxicity? Where does the arsenic in the Terai's groundwater come from? **[2]**

b. The family has two ideas: (i) keep using their own well but boil the water first, or (ii) carry water from a neighbor's tube well that tests at 30 μg/L. Judge each idea, with reasons. **[2]**

c. Sneha's grandfather, who has drunk from the well for thirty years, has dark spots and thick, hard skin on his palms and soles. Her younger brother, who has drunk the same water for two years, shows no signs at all, so he says the water can't be harming him. Is he right? Explain. **[1]**

Question 7 — 5 marks

Four alcohols and three ethers share the molecular formula $C_4H_{10}O$. One of the alcohols is butan-1-ol, $CH_3CH_2CH_2CH_2OH$.

a. Define functional isomerism. **[1]**

b. Write the condensed formula and IUPAC name of (i) a position isomer of butan-1-ol and (ii) a functional isomer of butan-1-ol. **[2]**

c. Which one of the four alcohols of formula $C_4H_{10}O$ shows optical isomerism? Give the reason, and say why the other three don't. **[2]**

Question 8 — 5 marks

Hydrogen bromide adds to propene, $CH_3–CH=CH_2$, but the product depends on whether a peroxide is present.

a. State Markovnikov's rule. What is the peroxide effect? **[2]**

b. Write the equations for the reaction of propene with HBr (i) without and (ii) with a peroxide, naming each product. **[2]**

c. Two unlabelled jars hold the isomers but-1-yne, $CH\equiv C–CH_2–CH_3$, and but-2-yne, $CH_3–C\equiv C–CH_3$. Both decolorize bromine water. Suggest a chemical test that tells them apart, with its result and the reason. **[1]**

Question 9 — 5 marks

Nepal imports every sack of urea its farmers use. Urea is made from ammonia, and almost all the world's ammonia is made by Haber's process, using hydrogen from natural gas or coal.

a. Ammonia plants run day and night. Is this batch or continuous processing? Define it. **[1]**

b. In Haber's process, $N_2(g) + 3\,H_2(g) \rightleftharpoons 2\,NH_3(g)$, $\Delta H = -92$ kJ. Explain why the plant uses a high pressure, about 200 atm, and why it uses an iron catalyst. **[2]**

c. Nepal has no natural gas but has surplus hydroelectricity in the wet season. Some propose a "green" ammonia and urea plant, with hydrogen made by the electrolysis of water. Give one argument for such a plant and one difficulty it would face. **[2]**

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

Question 10 — 8 marks

Railway workers in Biratnagar weld rails with the thermite reaction:

$$Fe_2O_3 + 2\,Al \longrightarrow Al_2O_3 + 2\,Fe$$

A charge contains 16 g of iron(III) oxide and 8.1 g of aluminium powder. (Fe = 56, Al = 27, O = 16)

a. What is a limiting reactant? **[1]**

b. Find the limiting reactant. **[2]**

c. Calculate the mass of iron that can be formed and the mass of aluminium left over. **[2]**

d. The workers collect only 9.5 g of iron from this charge. Calculate the percentage yield. Their foreman proposes adding more aluminium powder to each charge to raise the yield. Would that help? Explain, and say where the missing iron is more likely to have gone. **[3]**

Question 11 — 8 marks

In the school laboratory, Nishant heats a mixture of ammonium chloride and slaked lime in a hard-glass test tube and collects the gas in an upside-down gas jar.

a. Write the balanced equation for the reaction. Explain why the gas is collected in an upside-down jar, and why it is dried with quicklime and not with concentrated sulphuric acid. **[3]**

b. A moist red litmus paper held at the mouth of the jar turns blue. Why? **[1]**

c. Write the equations for what happens when (i) a glass rod dipped in concentrated hydrochloric acid is held at the mouth of the jar, and (ii) ammonia is passed into copper sulphate solution until it is in excess. **[2]**

d. Nishant then does the fountain experiment: a few drops of water squirted into a flask of ammonia make water rush up a tube from a beaker below. His teacher warns him that the flask and the ammonia must be perfectly dry beforehand, and that if the ammonia is mixed with some air, the water will stop before the flask is full. Explain both warnings. **[2]**

OR

In a fume cupboard, Rabina adds concentrated hydrochloric acid to manganese dioxide in a flask and warms it. The gas passes through a bottle of water, then a bottle of concentrated sulphuric acid, and is collected in an upright gas jar.

a. Write the balanced equation for the reaction. Explain why the gas is passed through water and then through concentrated sulphuric acid. **[3]**

b. Why is the gas collected in an upright jar, and not over water? **[1]**

c. Write the equations for the reaction of chlorine with (i) hot, concentrated and (ii) cold, dilute sodium hydroxide solution. **[2]**

d. Rabina holds a strip of moist blue litmus paper in the jar of chlorine. It first turns red, then white. Explain both changes, with equations. **[2]**

Question 12 — 8 marks

In 1865 August Kekulé proposed the structure of benzene, C_6H_6, shown below: a ring of six carbon atoms joined by alternate single and double bonds.

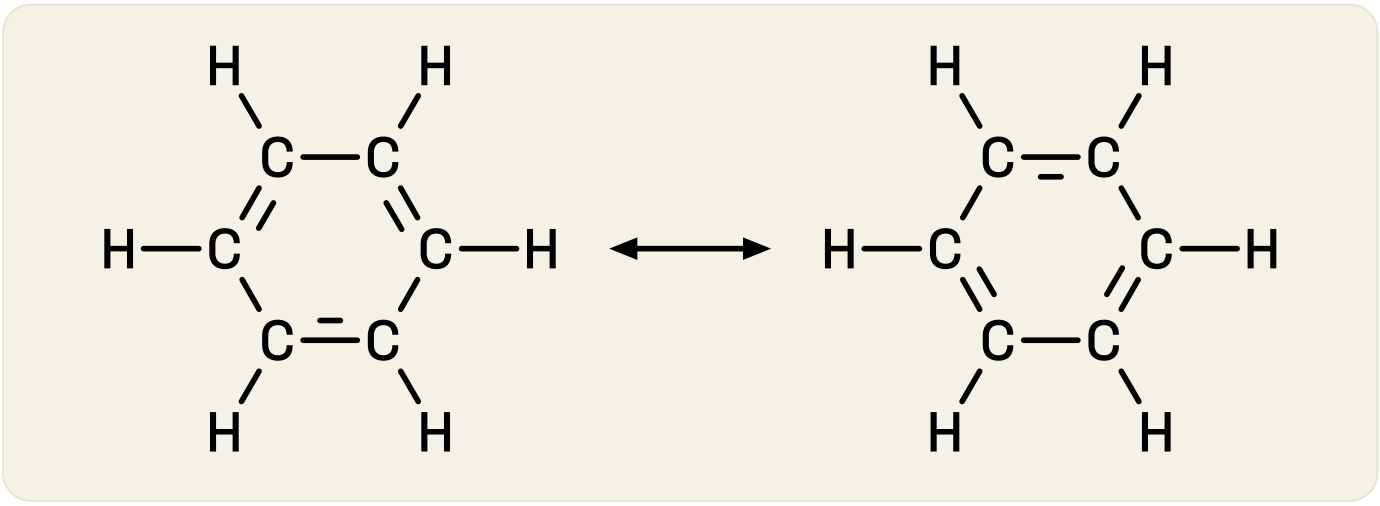


Figure 1 Kekulé's structures of benzene, joined by the resonance arrow.

a. Explain three facts about benzene that Kekulé's structure, with fixed single and double bonds, can't account for. **[3]**

b. Write the equation for the nitration of benzene, with the reagents and conditions, and name the electrophile. **[2]**

c. Benzene is unsaturated, yet it reacts with bromine (with an $FeBr_3$ catalyst) by substitution and not by addition. Explain why. **[2]**

d. In a refinery, catalytic reforming turns straight-chain hydrocarbons of naphtha into aromatic compounds such as benzene and toluene, which are blended into petrol. Why does this improve the petrol? **[1]**