IB Chemistry HL - Prediction Exams
May 2025 - Paper 2

Paper 2

7 questions | 150 mins | 90 marks

Filters | Go to Question

Difficulty

Easy | Medium | Hard

Question 1

Medium

[Maximum marks: 23]

Copper is widely used in electrical wiring, plumbing, coins, and industrial machinery due to its excellent conductivity, corrosion resistance, and malleability.

(a) Draw a labelled diagram to show how the particles are arranged in copper solid. [2]

(b) Explain the electrical conductivity of copper in terms of its structure. [2]

(c) The first ionization energy of copper is 745 kJ mol^{-1}. Calculate the wavelength of convergence, in nm, for the copper atomic emission spectrum. [3]

(d) A copper sample is analyzed, and the percentage composition is $68\%\ {}^{63}_{29}\mathrm{Cu}$ and $32\%\ {}^{65}_{29}\mathrm{Cu}$.

(i) Calculate the relative atomic mass of the sample to two decimal places. [2]

(ii) A researcher drew the conclusion that the copper sample must have come from a meteorite, and was not from Earth. Evaluate this conclusion. [2]

(iii) State the number of protons and neutrons in copper-63. [1]

(iv) Draw the orbital box diagram for the valence electrons in copper-63. [2]

(e) Copper is extracted from the earth's crust. Its extraction is performed by roasting and reducing $\mathrm{Cu_2S(s)}$.

$$2\ \mathrm{Cu_2S(s)} + 3\ \mathrm{O_2(g)} \xrightarrow{heat} 2\ \mathrm{Cu_2O(s)} + 2\ \mathrm{SO_2(g)}$$

$$2\ \mathrm{Cu_2O(s)} + \mathrm{Cu_2S(s)} \xrightarrow{heat} 6\ \mathrm{Cu(s)} + \mathrm{SO_2(g)}$$

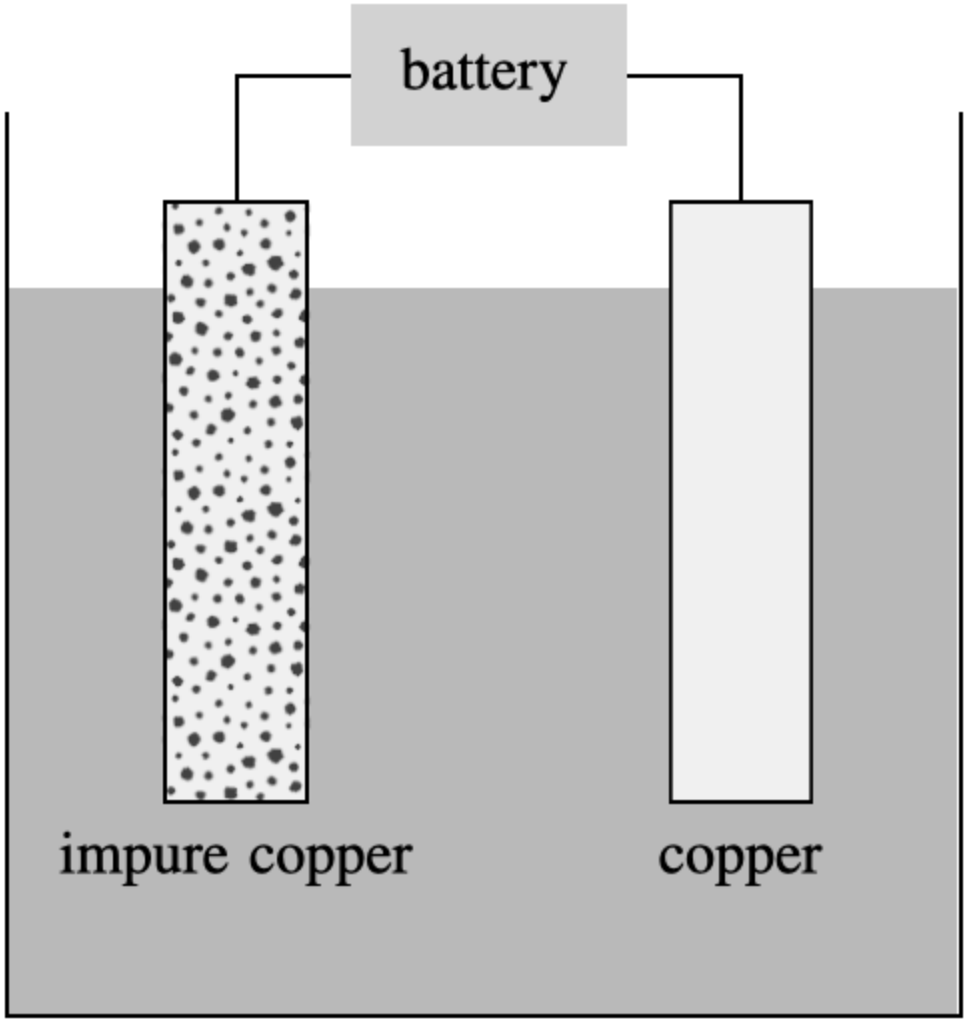
A $1.025\ \mathrm{g}$ sample of impure $\mathrm{Cu_2S}$ is processed to form $79.45\ \mathrm{cm^3}$ of $\mathrm{SO_2(g)}$ at STP.

(i) State the IUPAC name of $\mathrm{Cu_2S}$. [1]

(ii) Calculate the amount of $\mathrm{SO_2}$, in mol, produced. [2]

(iii) Deduce the percentage purity of $\mathrm{Cu_2S}$ in the roasted sample. [2]

(f) Impure copper can be refined in an electrolytic cell, as shown below.



(i) Annotate the direction of the electron flow and the position of the cathode on the diagram. [2]

(ii) Suggest two reasons why the mass lost at one electrode differs from the mass gained at the other. [2]

Formula Booklet

Question 2

Medium

[Maximum marks: 10]

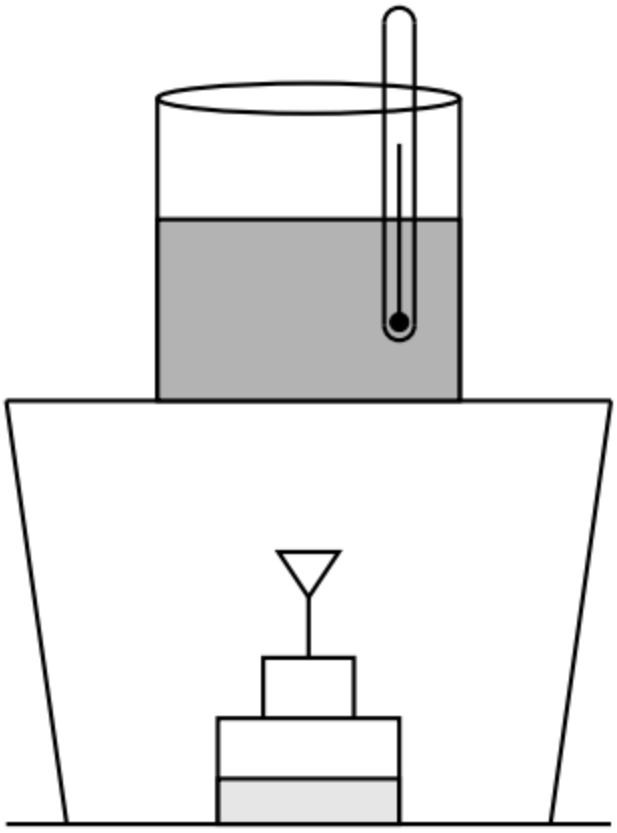
2−methylpropan−2−ol, $(CH_3)_3COH$ is a common additive used to increase the octane rating of fuel.

(a) Write the balanced equation for the complete combustion of $(CH_3)_3COH$. [1]

(b) Calculate the enthalpy of combustion of 2−methylpropan−2−ol using Section 12 of the IB Chemistry data booklet. [3]

(c) The accepted value for the enthalpy of combustion is -2644 kJ mol^{-1}. Suggest the best explanation for the difference between the accepted value and the value obtained in (b). [1]

(d) A student carried out an experiment to determine the enthalpy of combustion of 2−methylpropan−2−ol using a spirit burner as shown here, and collected the data below.



mass of water	150.0 ± 0.1 g
initial temperature	23.2 ± 0.1°C

mass of water	150.0 ± 0.1 g
final temperature	$50.0 \pm 0.1^{\circ}$C
initial mass of spirit burner	134.2 ± 0.1 g
final mass of spirit burner	133.6 ± 0.1 g

Using Sections 1 and 2 of the IB Chemistry data booklet, calculate the experimental enthalpy of combustion. [3]

(e) Calculate the percent uncertainty in the mass of $2-$methylpropan$-2-$ol combusted. [1]

(f) Justify whether random or systematic error dominates this experiment. [1]

Revisit | Complete

Mark Scheme

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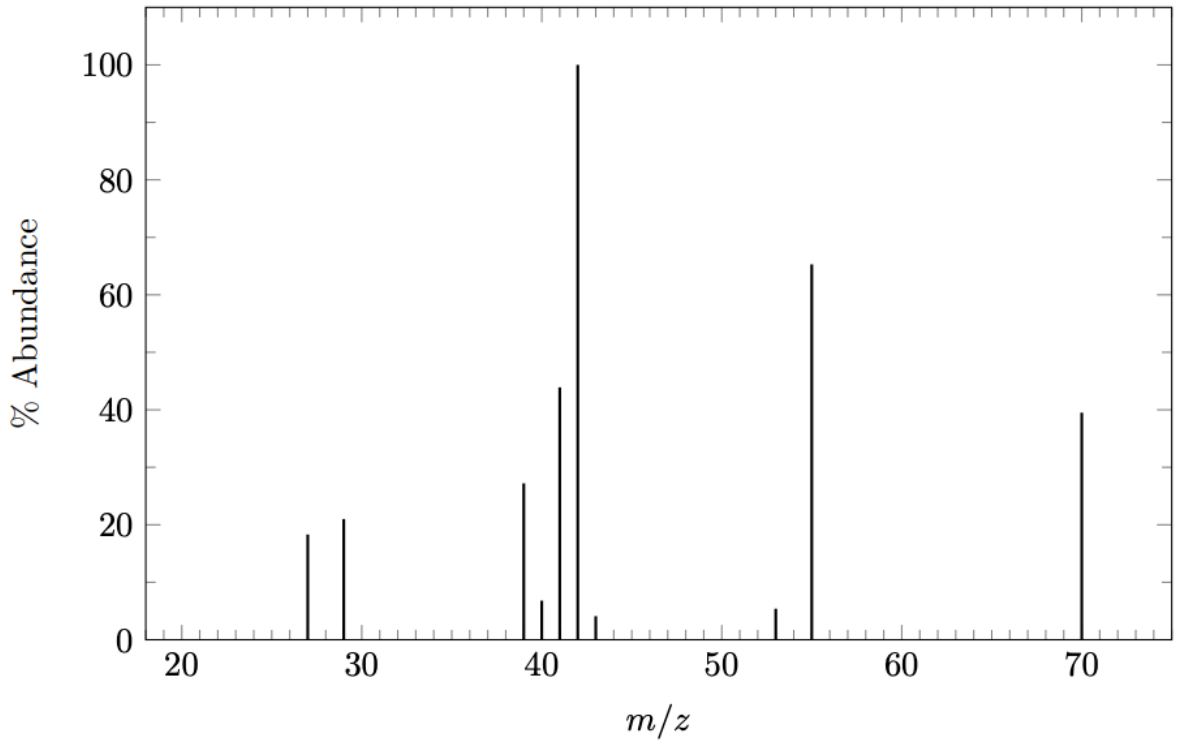
Question 3

Medium

A hydrocarbon C_xH_y can be used as a gasoline additive.

(a) It is 14.4% hydrogen. Deduce the empirical formula of the hydrocarbon. [2]

(b) The mass spectrum of the hydrocarbon is given below.



(i) Determine the relative molar mass of the compound and deduce the formula of the molecular ion. [2]

(ii) Deduce the formula of the fragment responsible for the peak at 55. [1]

(c) The IR spectrum shows a strong peak at 1643 cm^{-1}. Using Section 20 of the IB Chemistry data booklet, suggest the bond responsible. [1]

(d) The ^1H NMR of the compound has five signals tabulated here:

Chemical shift /ppm	Integration trace	Splitting pattern
0.91	3	triplet
1.43	2	multiplet
2.02	2	multiplet
4.95	2	doublet
5.81	1	multiplet

Suggest the skeletal structure and IUPAC name of the hydrocarbon. [2]

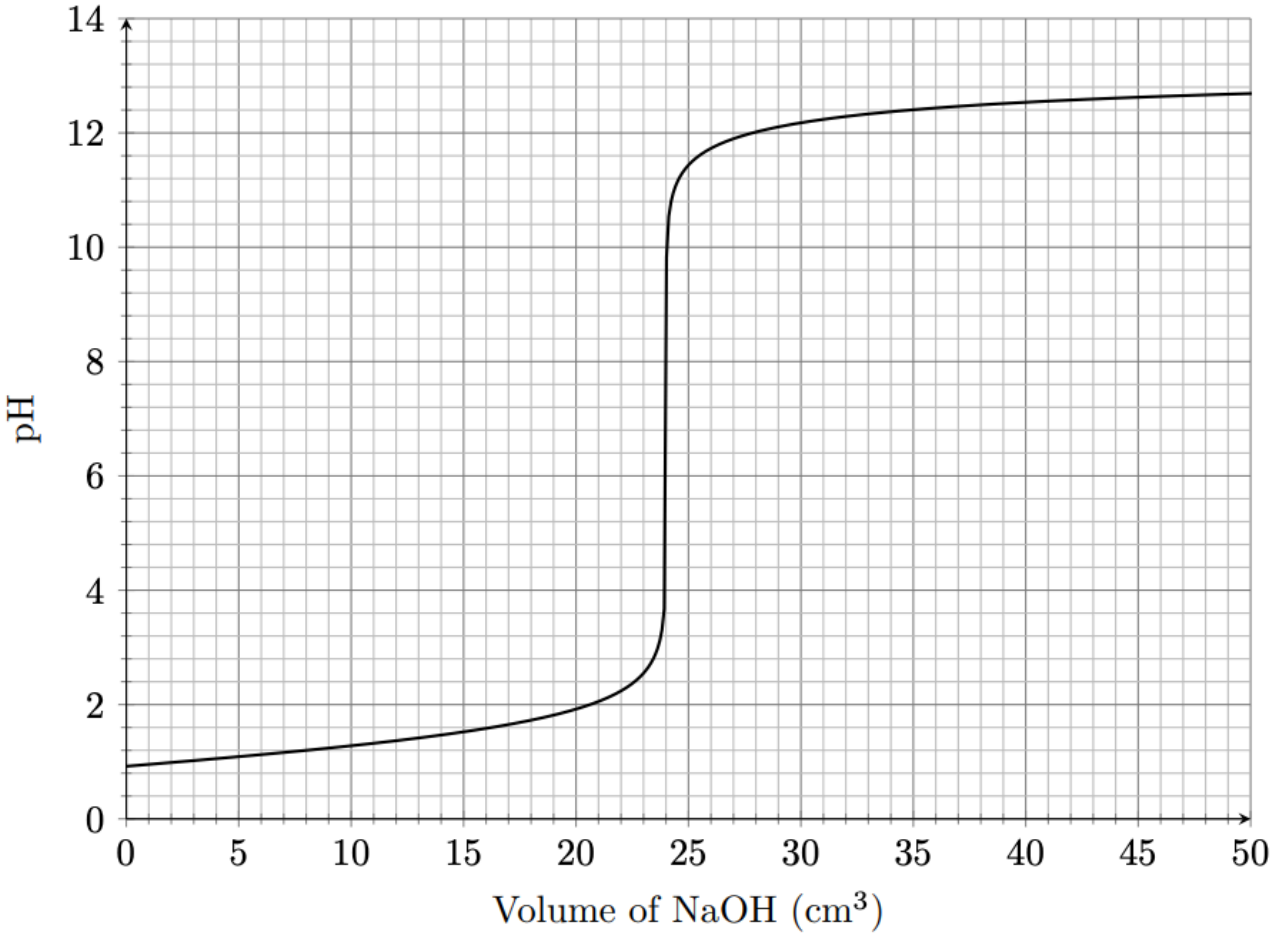
Formula Booklet

Question 4

Medium

[Maximum marks: 10]

A student produced the following curve upon titrating 30.0 cm^3 of nitric (V) acid, HNO_3, with 0.150 mol dm^{-3} sodium hydroxide, NaOH.



(a) Determine the concentration of the nitric (V) acid, HNO_3. [1]

(b) Sketch, on the graph above, the pH curve expected if the concentration of NaOH is doubled. [3]

(c) State and explain one similarity and one difference in the pH curve if the nitric (V) acid were replaced with nitric (III) acid, HNO_2 of the same concentration. [3]

(d) Identify an indicator in Section 18 of the IB Chemistry data booklet that could be used to determine the equivalence point of the titration of $HNO_2(aq)$ and NaOH(aq). [1]

(e) Using the formula HIn to represent the indicator, explain why the indicator changes colour during the titration. [2]

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Question 5

Medium

[Maximum marks: 14]

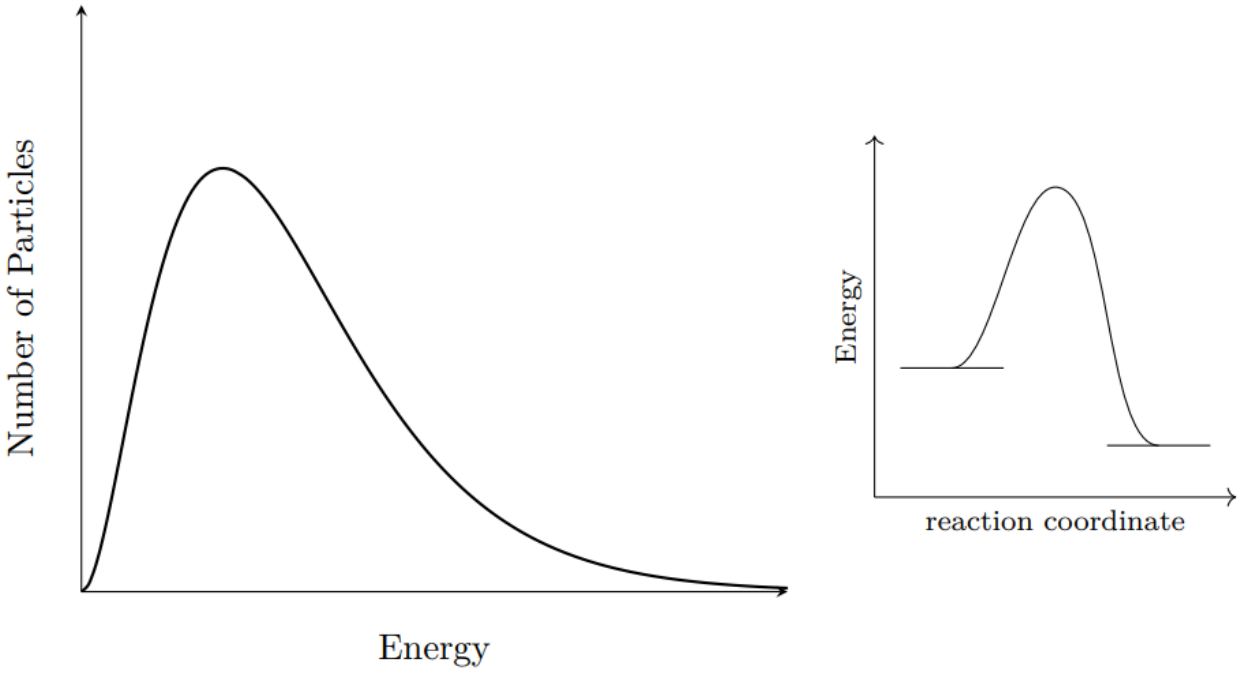
Consider the formation of methanol

$$CO(g) + 2\,H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H = -90.2\ \text{kJ mol}^{-1}$$

(a) Deduce the equilibrium constant expression. [1]

(b) State and explain the effect of an increase in pressure on the yield of methanol. [2]

(c) Mixtures of copper and zinc oxide catalyze the reaction. Annotate the effect of a catalyst on the diagrams below. [2]



(d) Predict the sign, giving a reason, for the standard entropy change for the formation of methanol above. [2]

(e) Qualitatively evaluate the spontaneity of methanol production at different temperatures and comment on the change in value of the Gibbs free energy as temperature increases. [2]

(f) An alternative method to produce methanol is the nucleophilic substitution reaction of chloromethane with warm, aqueous sodium hydroxide.

$$CH_3Cl + NaOH \longrightarrow CH_3OH + NaCl$$

(i) Explain the mechanism of this reaction using curly arrows to represent the movement of electron pairs. [3]

(ii) CH_3Cl can be produced from methane and Cl_2. Describe the initiation step for this mechanism, including conditions and curly arrows to represent the electron movement. [2]

Question 6

Medium

[Maximum marks: 8]

Alcohols are an important alternative fuel source.

(a) Outline two features of a homologous series. [2]

(b) Ethanol, a widely used biofuel, can be produced from various plant sources such as corn and sugarcane.

(i) Explain why biofuels are carbon neutral. [1]

(ii) Outline another advantage and one disadvantage of biofuels. [2]

(c) Methanol can be used in fuel cells.

(i) State the reactions that occur at the anode and cathode in a direct methanol fuel cell. [2]

(ii) Describe an advantage of the methanol fuel cell over the hydrogen fuel cell. [1]

Revisit | Complete

Mark Scheme

Video Solutions 5

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Question 7

Medium

[Maximum marks: 18]

Butenes are important raw materials used in the production of polymers, liquefied petroleum gas (LPG), and various chemical intermediates.

(a) But−2−ene exhibits configurational isomerism and can exist as two distinct isomers. Draw and name the two isomers. [2]

(b) Explain why but−1−ene does not exhibit configurational isomerism. [1]

(c) But−1−ene reacts with HBr. The major product occurs as a racemic mixture.

(i) Describe what is meant by racemic mixture. [1]

(ii) Draw both enantiomers of the product using dash-wedge notation. [2]

(d) The following rate of reaction experimental data was collected for the reaction of but−1−ene with hydrogen bromide.

Experiment	**[but−1−ene] /mol dm^{-3}**	**[HBr] /mol dm^{-3}**	**initial rate /mol dm^{-3} s^{-1}**
1	0.10	0.10	1.5×10^{-3}
2	0.20	0.10	3.0×10^{-3}
3	0.20	0.20	6.0×10^{-3}

(i) Deduce the rate expression. [2]

(ii) Calculate the rate constant for Experiment 1, stating its units. [2]

(e) (i) Explain the mechanism of the reaction between but−1−ene and hydrogen bromide using curly arrows to show the movement of electron pairs to form the ***minor*** adduct. [3]

(ii) Outline why 2−bromobutane is the major product. [1]

(iii) The major product, 2−bromobutane, can be directly converted to an intermediate compound, **X**, which can then be directly converted to the ketone, butanone.

$$\text{2−bromobutane} \longrightarrow \mathbf{X} \longrightarrow \text{butanone}$$

Identify **X**. [1]

(f) Suggest, with a reason, if the mechanism drawn in (e)(i) is consistent with the rate expression in part (d)(i). [2]

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