Practice Paper 2

Question Paper

Course	DP IB Chemistry
Section	Set C
Topic	Practice Paper 2
Difficulty	Medium

Time allowed: 110

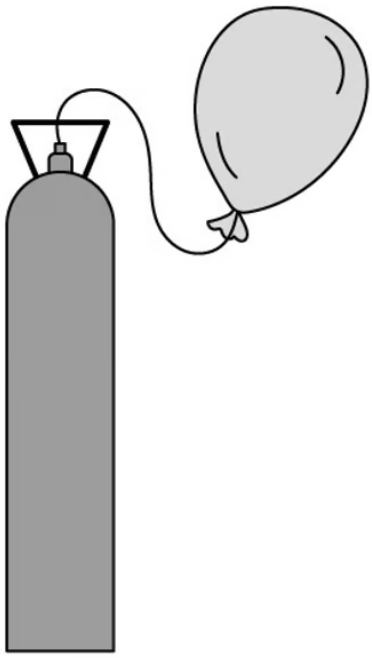
Score: /90

Percentage: /100

Question 1a

a) Gas cylinders of helium, like the one shown below, are sometimes used to inflate party balloons.

Figure 1



A typical 11-inch party balloon has a fully inflated volume of 14.1 dm^3. The pressure in the gas cylinders is 20,000 kPa. If the gas cylinder can fill 160 balloons at 298 K and 108 kPa, what is the total volume of helium inside the gas cylinder in dm^3?

[1 mark]

Question 1b

b) Sketch a graph to show the relationship between the volume and temperature of an ideal gas at constant pressure. Describe the relationship between the two variables.

[2 marks]

Question 1c

c) Deep sea divers sometimes breathe mixtures of helium and oxygen in their scuba diving tanks when the conditions are very deep, so they can avoid nitrogen narcosis.

If a bubble of gas escapes from a scuba tank at 60 m depth where the pressure is 588 kPa and the temperature is 8 ^{o}C, determine the increase in the size of the bubble by the time it reaches the surface where the pressure is 100 kPa and the temperature is 20 ^{o}C.

[2 marks]

Question 1d

d) Commercial aircraft are fitted with oxygen cannisters that provide a supply of oxygen in case of the loss of cabin pressure. The cannisters contain sodium chlorate(V) which produces oxygen in the following decomposition reaction.

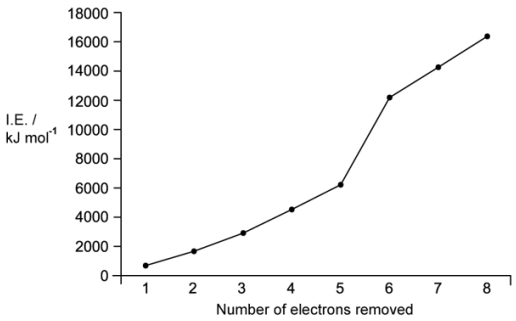
$$2NaClO_3\,(s) \rightarrow 2NaCl\,(s) + 3O_2\,(g)$$

Determine the mass of sodium chlorate(V) needed to produce 10.0 dm^3 of oxygen at 298 K and 90 kPa.

[4 marks]

Question 2a

a)
The successive ionisation energies of vanadium are shown.



State the sub-levels from which each of the first four electrons are lost

[2 marks]

Question 2b

b)
Outline why there is an increase in ionisation energy from electron 3 to electron 5.

[2 marks]

Question 2c

c)
Explain why there is a large increase in the ionisation energy between electrons 5 and 6.

[3 marks]

Question 2d

d)
The first six ionisation energies, in kJ mol^{-1}, of an element are shown below

IE_1	IE_2	IE_3	IE_4	IE_5	IE_6
578	1816	2744	11576	14829	18375

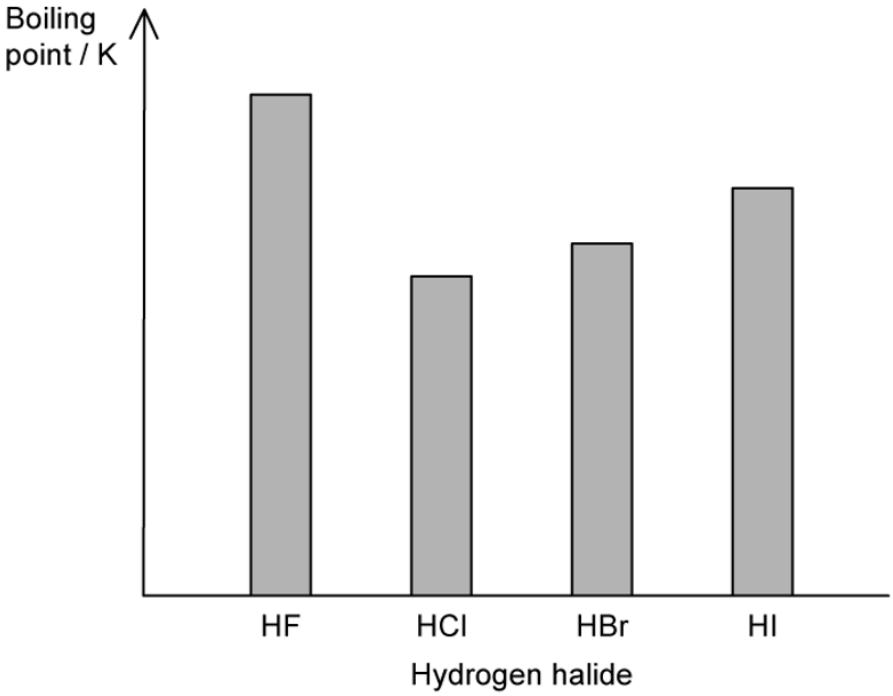
Explain the large increase in ionisation energy from IE_3 to IE_4

[2 marks]

Question 3a

a) The hydrogen halides do not show perfect periodicity. A bar chart of boiling points, as seen in Figure 1, shows that the boiling point of hydrogen fluoride, HF, is much higher than periodic trends would indicate.

Figure 1



Explain why the boiling point of HF is much higher than the boiling point of the other hydrogen halides.

[2 marks]

Question 3b

b) There is an increase in boiling point moving from HC*l* to HI.
Explain this trend in boiling points of the hydrogen halides.

[2 marks]

Question 3c

c) A student adds a solution containing silver ions to two test tubes containing chloride and bromide ions. The student observes that both solutions turn cloudy.

Explain the observation the student made upon carrying out the experiment.

[2 marks]

Question 4a

a)
When chromium(III) sulfate dissolves in water, a green solution containing the $[Cr(H_2O)_6]^{3+}$ ion forms.

i)
State the bond angles found in this complex ion.

[1]

ii)
Explain why the chromium(III) complex ion is coloured.

[3]

[4 marks]

Question 4b

b)
Vanadium(V) oxide is the catalyst used in the Contact process as shown by the reactions:

$$SO_2(g) + V_2O_5(s) \rightarrow SO_3(g) + V_2O_4(s)$$

$$V_2O_4(s) + ½O_2(g) \rightarrow V_2O_5(s)$$

i) Explain, using the equations, why V_2O_5 is a catalyst.

[1]

ii) Explain why V_2O_5 can act as a catalyst in this reaction.

[1]

[2 marks]

Question 4c

c)
Excess ammonia is added to a solution of Cu^{2+} ions resulting in the substitution of 4 ligands.
Using section 15 of the data booklet, explain why this reaction results in a shift in the wavelength of light absorbed by the Cu^{2+} complex.

[1]

[1 mark]

Question 5a

a) Draw the structure of silicon dioxide and state the type of bonding present.

[2 marks]

Question 5b

b) Describe the similarities and differences you would expect in the properties of silicon and diamond.

[3 marks]

Question 5c

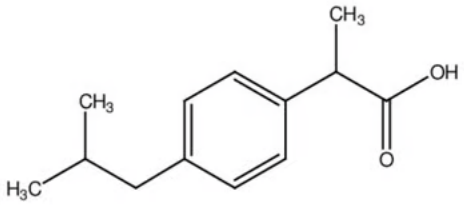
c) The boiling point of diamond is 3550 °C, but for carbon dioxide it is -78.5 °C. Both are covalent substances.

Explain this difference with reference to structure and bonding.

[4 marks]

Question 6a

a)
Ibuprofen is a common non-steroidal anti-inflammatory drug (NSAID). It contains a benzene ring and a carboxylic acid at the end of one of the branches.



Deduce the number of resonance structures possible in the deprotonated form of ibuprofen.

[1]

[1 mark]

Question 6b

b)
Deduce the number of:

i)
Sigma (σ) bonds in ibuprofen

[1]

ii)
Pi (π) electrons in ibuprofen

[1]

[2 marks]

Question 6c

c)
The ibuprofen molecule contains both sp^3 and sp^2 hybridised orbitals.

i)
Identify how many sp^3 hybrid orbitals are present.

[1]

ii)
Identify how many sp^2 hybrid orbitals are present.

[1]

[2 marks]

Question 6d

d)
Explain why the benzene ring is a regular, planar hexagon.

[3]

[3 marks]

Question 7a

a)
State the formula for calculating the standard enthalpy change of reaction, ΔH_r, using bond energies.

[1 mark]

Question 7b

b)

Use section 11 of the data booklet to calculate the enthalpy change, in kJ mol^{-1}, for the following reaction.

$$Cl_2 + H_2 \rightarrow 2HCl$$

[4 marks]

Question 7c

c)

State whether the energy change for the reaction in part (b) is endothermic or exothermic.

[1 mark]

Question 7d

d)

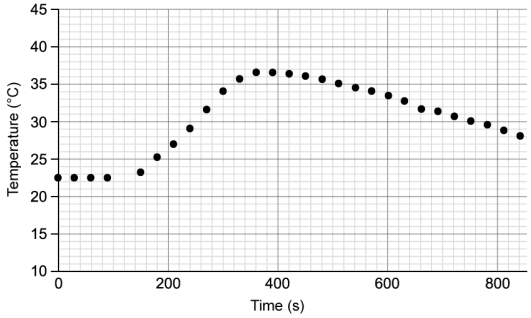
Using section 11 of the data booklet, calculate the enthalpy change of reaction, ΔH_r, in kJ mol^{-1} for the following reaction.

$$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$$

[4 marks]

Question 8a

a)
A student measured the energy change when 1.35 g of zinc was added to 50 cm^3 of 0.5 mol dm^{-3} copper sulfate, $CuSO_4$ (aq), solution. The initial temperature of 21 °C was recorded before the addition of the zinc and a temperature reading was taken every 30 seconds.



Use the graph to determine the overall temperature change for the reaction

[1 mark]

Question 8b

b)
Calculate the enthalpy change for the reaction in kJ mol^{-1}.

[4 marks]

Question 8c

c)
Calculate the percentage error between your value for the enthalpy change of reaction and the literature value of -217 kJ mol^{-1}. Give your answer to two significant figures.

[1 mark]

Question 8d

d)
Explain why your calculated value for the enthalpy change of reaction is different from the literature value of -271 kJ mol^{-1}.

[3 marks]

Question 9a

a)
Define the term *nucleophile*.

[2]

[2 marks]

Question 9b

b)
Explain why the hydroxide ion, OH^-, is a stronger nucleophile than water.

[2]

[2 marks]

Question 9c

c)
State the two ways a nucleophilic substitution reaction can occur.

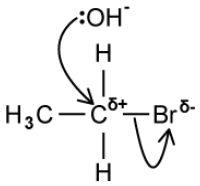
[1]

[1 mark]

Question 9d

d)

State the the name of the mechanism occurring in the image below which will form ethanol in one step.



[1]

[1 mark]

Question 10a

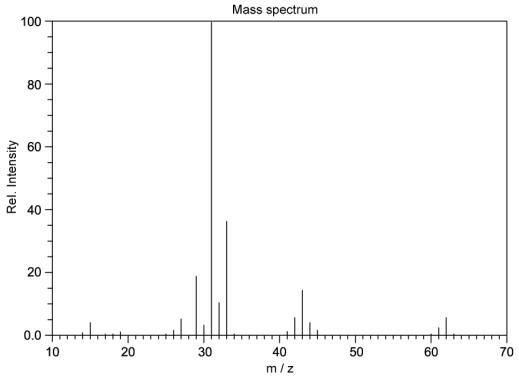
a)

Ethane-1,2-diol, $C_2H_6O_2$, can be distinguished from ethanedioic acid, $C_2H_2O_4$, by a number of analytic techniques including MS, IR and NMR

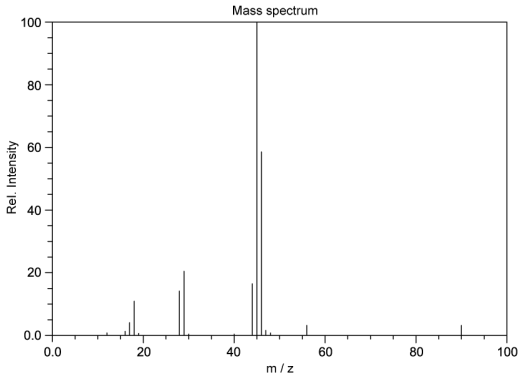
The MS of these molecules is shown below.

Which spectrum belongs to each molecule? Justify your answer.

Spectrum **A**



Spectrum **B**



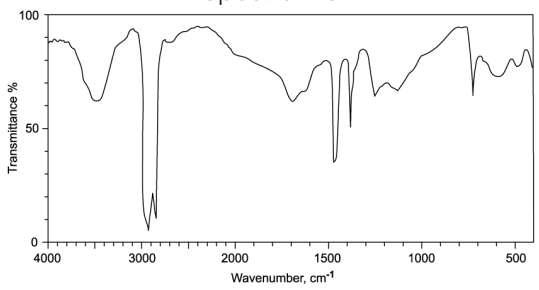
[2 marks]

Question 10b

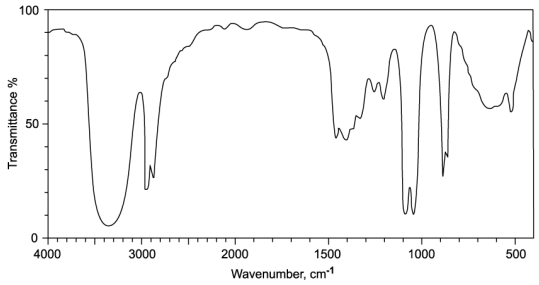
b)

The IR spectra of ethane-1,2-diol, $C_2H_6O_2$, and ethanedioic acid dihydrate, $C_2H_2O_4.2H_2O$, are shown in spectrum **C** and **D**. Use Section 26 of the Data Booklet to answer this question.

Spectrum **C**



Spectrum **D**



Which spectrum belongs to each molecule? Justify your answer.

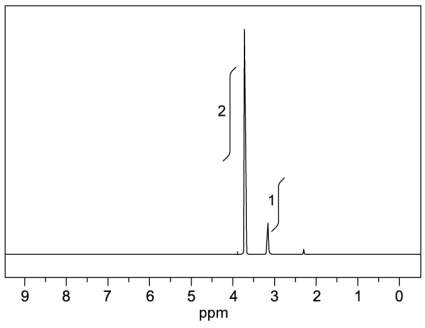
[2 marks]

Question 10c

c)

The ^1H NMR spectrum of ethane-1,2-diol is shown in spectrum **E**. Explain the significance of the spectrum.

Spectrum **E**



[3 marks]

Question 11a

a) The Winkler method is a chemical technique used to measure the concentration of dissolved oxygen in water samples. The method involves treating the samples to convert the dissolved oxygen into iodine which is then titrated against standard sodium thiosulfate solution as shown below:

Step 1: $2Mn^{2+}(aq) + O_2(aq) + 4OH^-(aq) \rightarrow 2MnO_2(s) + 2H_2O(l)$

Step 2: $MnO_2(s) + 2I^-(aq) + 4H^+(aq) \rightarrow Mn^{2+}(aq) + I_2(aq) + 2H_2O(l)$

Step 3: $2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$

A student wanted to check if the water in a fish tank was sufficiently oxygenated and analysed two 500 cm^3 samples, five days apart.

The following results in **Table 1** were obtained when the resulting iodine was titrated against 0.0120 $moldm^{-3}$ $Na_2S_2O_3$ (aq).

Table 1
Oxygen analysis in fish tank water on day 0

Initial burette reading / cm^3 ± 0.1cm^3	0.20
Final burette reading / cm^3 ± 0.1cm^3	26.0
Titre / cm^3	

i) Determine the reacting ratio by moles of $S_2O_3^{2-}$ to O_2, using the balanced equations in steps 1-3.

ii) Calculate the titre and determine the percentage uncertainty in the reading.

[3 marks]

Question 11b

b) Determine the number of moles of oxygen in the 500 cm^3 sample and hence the concentration in ppm.

[3 marks]

Question 11c

c) It is generally considered that dissolved oxygen levels of at least 4-5 ppm are sufficient for most aquatic life. The day 5 sample contained 5.03×10^{-5} moles of oxygen.

Discuss whether the student should be concerned about the oxygen levels in the fish tank over the 5-day period.

[2 marks]

Question 11d

d)
Suggest two modifications to the procedure which would make the result more reliable.

[2 marks]