IB · DP · Chemistry

2 hours 11 questions

Practice Paper 2

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Total Marks **/90**

1 (a) The periodic table displays the chemical elements, arranged in order of increasing atomic number. It is made up of groups and periods of elements.

State and explain the general trend in first ionisation energy across a period of the periodic table.

(4 marks)

(b) The general trend in first ionisation energies stated in part (a) is seen across period 2 of the periodic table. However, boron and one other period 2 element deviate from this trend.

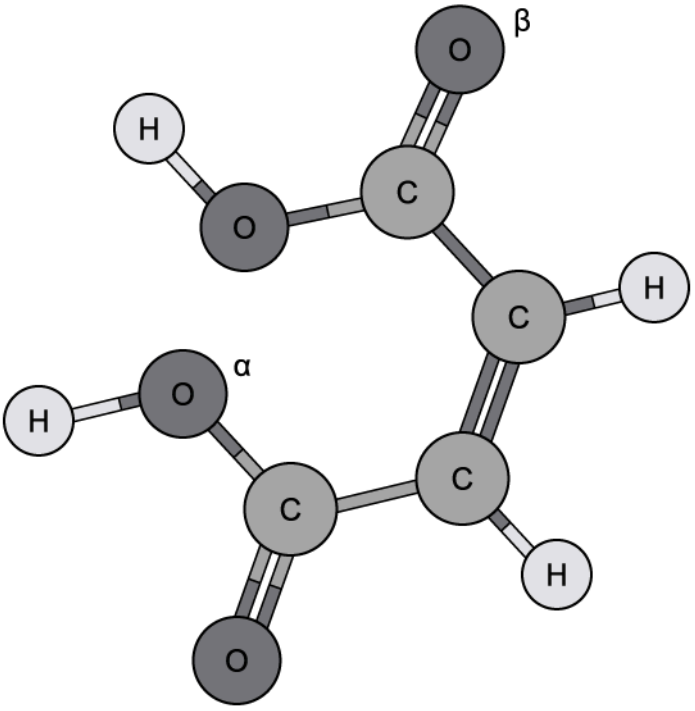
Identify this element and explain why it deviates from the general trend.

(3 marks)

(c) State why nitrogen is classed as a p block element and give its full electron configuration.

(2 marks)

2 (a) But-2-ene-1,4-dioic acid exists as both cis and trans isomers. The cis isomer is shown below



Describe the type of covalent bond between carbon and hydrogen in the molecule shown above and how it is formed.

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(2 marks)

(b) Identify how many sigma bonds and how many pi (π) bonds are present in cis but-2-ene-1,4-dioc acid.

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(2 marks)

(c) Draw the Lewis structures, predict the shape and deduce the bond angles for xenon tetrafluoride.

(3 marks)

3 (a) Tetrafluoroethene, C_2F_4, and tetrafluorohydrazine, N_2F_4, are fluorides of adjacent elements in the Periodic Table.

Draw the Lewis (electron dot) structures for C_2F_4 and N_2F_4 showing all valance electrons.

(2 marks)

(b) Predict and explain the F-C-F bond angle in tetrafluoroethene and the F-N-F bond angle in tetrafluorohydrazine.

(5 marks)

(c) Tetrafluorohydrazine is a polar molecule but tetrafluoroethene is not.

Explain the difference in molecular polarity.

(4 marks)

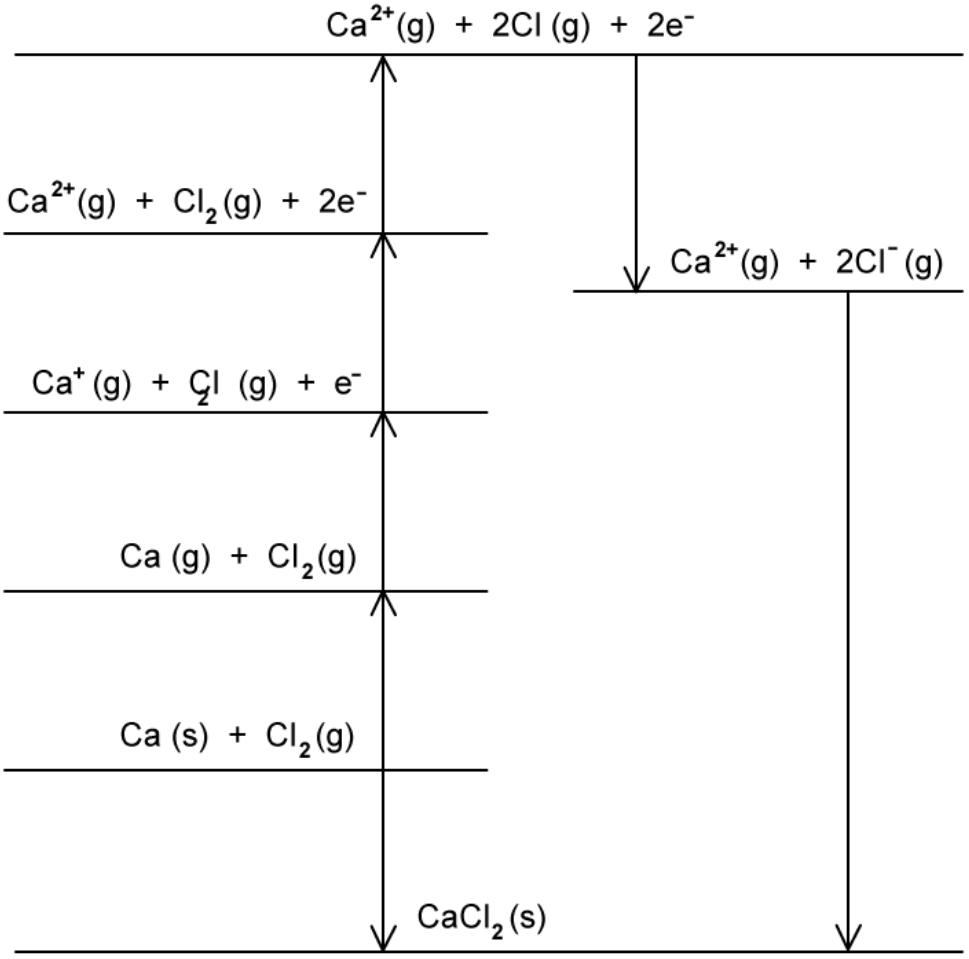
4 (a) Calcium chloride has many uses including as an agent to lower the freezing point of water. It is very effective for preventing ice formation on road surfaces and as a deicer.

i) Define the term ionisation energy

ii) Explain why the second ionisation energy of calcium is greater than the first ionisation energy

(5 marks)

(b) The Born-Haber cycle for $CaCl_2$ is shown:



Using Section 8 in the Data Booklet and the following information, calculate the enthalpy change for the following conversions.

ΔH^{θ}_{IE2} Ca = 1145 kJ mol^{-1}

ΔH^{θ}_{at} Ca = 178 kJ mol^{-1}

ΔH^{θ}_{BE} Cl_2 = 242 kJ mol^{-1}

i) $Ca(s) \rightarrow Ca^{2+}(g) + 2e^-$ii)

$Cl_2(g) + 2e^- \rightarrow 2Cl^-(g)$

(2 marks)

(c) Using Section 18 of the Data Booklet, calculate the value for the enthalpy of formation for calcium chloride, $\Delta H^{\theta}_{f}\ CaCl_2$.

(2 marks)

5 (a) Aluminium oxide reacts with magnesium to form magnesium oxide and aluminium in a displacement reaction via the following reaction.

Construct a Hess's Law cycle for this reaction

$$Al_2O_3\,(s) + 3Mg\,(s) \rightarrow 3MgO\,(s) + 2Al\,(s)$$

Enthalpy of formation	Enthalpy of formation (kJ mol^{-1})
$\Delta H_f\,(Al_2O_3)$	-1675.7
$\Delta H_f\,(MgO)$	-601.7
$\Delta H_f\,(Mg)$	
$\Delta H_f\,(Al)$	

(4 marks)

(b) Outline why no values are listed for Al (s) and Mg (s) in the table given in part (a).

(1 mark)

(c) Calculate the enthalpy change of reaction, ΔH_r, for the reaction in part (a).

(2 marks)

6 (a) Glycolic acid, $C_2H_4O_3$, is a colourless, odourless crystalline solid that is highly soluble in water and behaves as a Brønsted–Lowry acid.

i) Define the term Brønsted–Lowry acid.

ii) State one difference between Brønsted–Lowry acids and the traditional theory of acids as substances that dissociate in water to form hydrogen ions.

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(2 marks)

(b) The systematic IUPAC name for glycolic acid is 2-hydoxyethanoic acid.

Draw the structural formula for its conjugate base, showing **all** the atoms and bonds.

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(1 mark)

(c) Write an equation for the reaction between glycolic acid, $C_2H_4O_3$, and limescale, $CaCO_3$. State and explain one observation you would make.

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(2 marks)

Monochloroacetic acid, ClH_2COOH, is a skin irritant that is used in "chemical peels" intended to remove the top layer of dead skin from the face and ultimately improve the complexion.

7 (a) Write an expression for the acid dissociation constant, K_a, of monochloroacetic acid.

(1 mark)

(b) Calculate the pH of a 0.05 M solution of monochloric acid.

The value of K_a for monochloroacetic acid is 1.35×10^{-3} mol dm^{-3}

(4 marks)

(c) Using Section 2 of the Data Booklet, calculate the value of $[OH^-]$ for the solution of monochloric acid.

(2 marks)

8 (a) A 0.680 mol sample of SO_3 is introduced into a 3.04 dm^3 reaction container and allowed to reach equilibrium at temperature *T*.
32% of the SO_3 had decomposed.

Calculate the value for K_c in this reaction, giving your answer to 2 significant figures.

$$2\ SO_3\ (g) \rightleftharpoons 2\ SO_2\ (g) + O_2\ (g) \qquad \Delta H = +196\ kJ\ mol^{-1}$$

(6 marks)

(b) The size of the container for the reaction in part (a) is decreased.
State the effect if any on the equilibrium constant, K_c, and the position of equilibrium.
Justify your answer.

(4 marks)

(c) Comment on whether the reaction in part (a) is likely to take place spontaneously at temperature *T*.

(2 marks)

9 (a) The formulae of four organic compounds are given in **Table 1**. Write the names of the compounds in the second column.

Table 1

compound	name
$CH_3CH_2CH_2CH(OH)CH_3$	
$CH_3CH_2COCH_3$	
$CH_3CH_2CH_2OH$	
$CH_3CH_2CH_2CHO$	

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(2 marks)

(b) Which of the compounds in part (a) are structural isomers of each other and what type of isomerism do they show?

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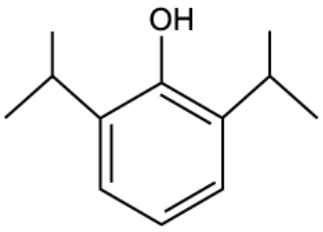
(2 marks)

(c) Propofol is a drug used to reduce consciousness during medical procedures. The skeletal structure of propofol is given in Figure 1.

Figure 1



i) Determine the empirical formula of propofol.

ii) Identify the number of positional isomers of propofol (not including propofol).

iii) State the names of two functional groups found in propofol.

(3 marks)

(d) Valeric acid, $C_5H_{10}O_2$, is a straight chain carboxylic acid found in the plant *Valeriana officinalis*.

i) State the general formula for a carboxylic acid.

ii) Give the systematic name for valeric acid.

iii) Draw a condensed structural formula for valeric acid.

(3 marks)

10 (a) Define the term *stereoisomers*.

(1 mark)

(b) State the conditions needed for a compound to show cis-trans isomerism.

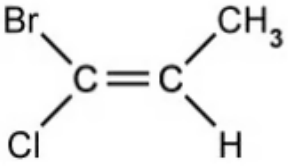
(2 marks)

(c) Draw the structural formulae for the *E* and *Z* stereoisomers of pent-2-ene.

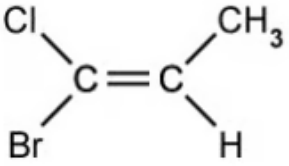
(2 marks)

(d) 2-bromo-1-chloropropene is a colourless, odourless liquid.

A student drew the two stereoisomers of 2-bromo-1-chloropropene below.



E-2-bromo-1-chloropropene



Z-2-bromo-1-chloropropene

State what is incorrect with their diagrams of these two stereoisomers.

(2 marks)

11 (a) Outline what chemical information can be obtained about inorganic ionic substances and complex organic molecules from X-ray crystallography studies.

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(2 marks)

(b) Explain why X-ray crystallography is not very useful for compounds containing hydrogen.

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(2 marks)

(c) Suggest another limitation of X-ray crystallography for organic compounds.

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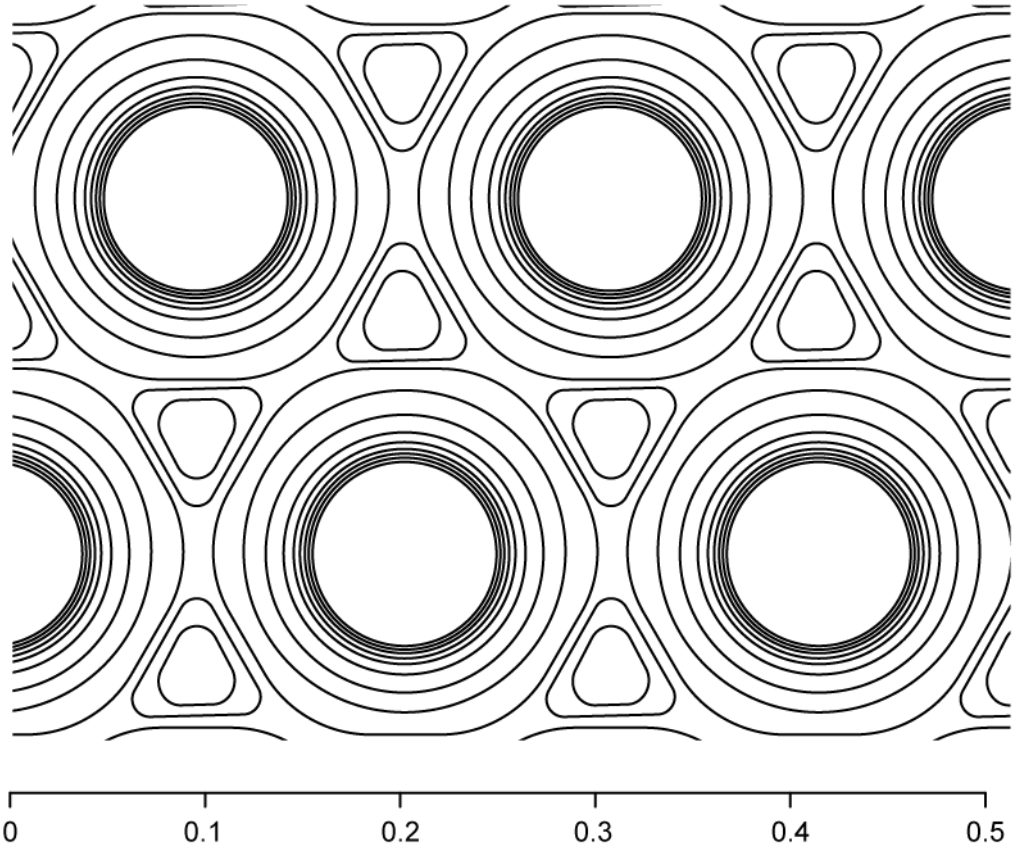
(1 mark)

(d) An electron density map obtain from the X-ray crystallography of copper metal is shown below:



Use the diagram to estimate the radius of a copper atom. The units are nm.

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(1 mark)