4.1 Ionic & Covalent Bonding

Question Paper

Course	DP IB Chemistry
Section	4. Chemical Bonding & Structure
Topic	4.1 Ionic & Covalent Bonding
Difficulty	Medium

Time allowed: 70

Score: /53

Percentage: /100

Question 1a

a) Calcium sulfide is an ionic solid that is phosphorescent and glows in the dark after a light source is removed.

i) Describe the nature of the bonding in calcium sulfide.

ii) State one physical property of calcium sulfide.

[2 marks]

Question 1b

b) Suggest why the melting point of calcium sulfide is much higher than that of elemental calcium or sulfur.

[3 marks]

Question 1c

c) Calcium sulfide has a lattice structure similar to sodium chloride.
Describe the lattice structure of calcium sulfide and draw a representative 3D diagram.
Label each ion and use different size spheres to distinguish between the different types of ions present.

[4 marks]

Question 1d

d) State the formula of calcium phosphate and calcium hydroxide.

[2 marks]

Question 2a

a) Ammonia, NH_3, is a chemical which is key in the manufacture of certain fertilisers and cleaning products.

An ammonia molecule will react with an H^+ ion, to form the ammonium ion, NH_4^+.

Draw a Lewis (electron dot) diagram to show the bonding in the ammonium ion and name the type of bond formed between the ammonia molecule and the hydrogen ion.

[2 marks]

Question 2b

b) Lewis (electron dot diagrams) are used to show the electron arrangement in the valence shells of covalently bonded molecules.

Draw Lewis diagrams for the following molecules:

(i) Hydrogen cyanide.

(ii) Carbon dioxide.

(iii) Boron trifluoride.

[3 marks]

Question 2c

c) Using your answer to part (b), identify and explain the species that is likely to form a coordinate covalent bond.

[2 marks]

Question 2d

d) Using your answer to part (c), Explain, with the help of a diagram, the covalent bond formed between the species in part (c) and ammonia.

[3 marks]

Question 3a

a) For each of the molecules below, draw the Lewis (electron dot) structure and use the valence shell electron pair repulsion theory (VSEPR) to predict the shape of each molecule.

Oxygen difluoride (OF_2), phosphorus trifluoride, (PF_3) and boron trichloride, (BCl_3).

[6 marks]

Question 3b

b) Crystalline ionic compounds do not conduct electricity.

State and explain in which states ionic compounds conduct electricity.

[2 marks]

Question 3c

c) The melting point of sodium chloride, NaCl, is 801° C.

Explain, with reference to structure and bonding, why sodium chloride melts at such a high temperature.

[3 marks]

Question 3d

d) We can use electronegativity values to deduce whether a compound is likely to be ionic or covalent.

Use Table 7 of the Data Booklet to state and explain whether each of the following compounds are ionic or covalent:

ICl

$SrCl_2$

RbI

HI

[2 marks]

Question 4a

a) Diimide, N_2H_2, is a useful reagent in organic synthesis and can be made by the thermal decomposition of azodicarboxylic acid

$$(NCOOH)_2\,(g) \rightarrow N_2H_2\,(g) + 2CO_2\,(g)$$

Another useful compound of nitrogen is hydrazine, N_2H_4.

Draw Lewis (electron dot) structures for diimide and hydrazine.

[2 marks]

Question 4b

b) Deduce the molecular geometry of diimide and estimate its H–N–N bond angle.

[2 marks]

Question 4c

c) List, with an explanation, the three compounds in order of increasing carbon to oxygen bond length (shortest first).

H_3COCH_3 $\quad$ CO $\quad$ CO_2

[3 marks]

Question 4d

d) Use Table 8 of the Data Booklet to predict which bond in each of the following pairs is more polar:

(i) C–H or C–Cl

(ii) Si–Li or Si–Cl

[2 marks]

Question 5a

a) Three types of covalent bonds are present in the molecules in the following equation.

$$2C_2H_2\,(g) + 5O_2\,(g) \rightarrow 4CO_2\,(g) + 2H_2O\,(l)$$

Identify **one** bond in these molecules that is correctly described by the following.

(i) A polar single bond.

(ii) A non-polar double bond.

(iii) A non-polar triple bond.

[3 marks]

Question 5b

b) Explain which of the bonds in part (a) is the shortest.

[2 marks]

Question 5c

c) **Table 1** shows the carbon-carbon bond enthalpy values for three different hydrocarbons.

Table 1

Hydrocarbon	C_2H_6	C_2H_4	C_2H_2
Bond enthalpy / kJ mol^{-1}	346	614	839

Explain the difference in carbon-carbon bond enthalpy values for the three hydrocarbons.

[3 marks]

Question 5d

d) We can use electronegativity values to deduce whether a compound is likely to be pure covalent(non-polar) or polar covalent.

Use Table 8 of the Data Booklet to state and explain whether each of the following covalent compounds are polar or non-polar:

H_2

HCl

CO

[2 marks]