5.3 Bond Enthalpy

Question Paper

Course	DP IB Chemistry
Section	5. Energetics / Thermochemistry
Topic	5.3 Bond Enthalpy
Difficulty	Hard

Time allowed: 20

Score: /10

Percentage: /100

Question 1

In the gas phase, phosphorus pentachloride can be thermally decomposed into gaseous phosphorus trichloride and chlorine.

$$PCl_5 \rightarrow PCl_3 + Cl_2$$

The table below gives the relevant bond energies found in these compounds.

bond	bond energy / kJ mol^{-1}
P–Cl (in both chlorides)	x
Cl–Cl	y

What is the enthalpy change in the decomposition of the reaction?

A. $y - 2x$

B. $2x - y$

C. $8x + y$

D. $x + y$

[1 mark]

Question 2

Which equation correctly shows how the bond energy for the covalent bond Y–Z can be calculated by dividing ΔH by n?

A. $nYZ(g) \rightarrow nY(g) + \frac{n}{2} Z_2(g)$

B. $Z(g) + YZ_{n-1}(g) \rightarrow YZ_n(g)$

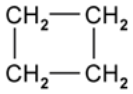
C. $2YZ_n(g) \rightarrow 2YZ_{n-1}(g) + Y_2(g)$

D. $YZ_n(g) \rightarrow Y(g) + nZ(g)$

[1 mark]

Question 3

The diagram shows the skeletal formula of cyclobutane.



The enthalpy change of formation of cyclobutane is +75.1 kJ mol^{-1}, and the enthalpy change of atomisation of graphite is +712 kJ mol^{-1}.

The bond enthalpy of C–H is 414 kJ mol^{-1} and of H–H is 436 kJ mol^{-1}.

What is the average bond enthalpy of the C–C bond in cyclobutane?

A. $712 - 436 + 2(414) + \frac{75.1}{4}$

B. $712 + 436 - 414 - \frac{75.1}{4}$

C. $712 + 436 - 2(414) - \frac{75.1}{4}$

D. $712 + 436 - 2(414) - 75.1$

[1 mark]

Question 4

Butane can be produced by the hydrogenation of buta-1,3–diene.

$$C_4H_6(g) + 2H_2(g) \rightarrow C_4H_{10}(g) \qquad \Delta H = -248 \text{ kJ mol}^{-1}$$

Bond	C-C	C-H	H-H
Mean bond enthalpy / kJ mol^{-1}	346	414	436

Using the information, which calculation shows the bond enthalpy for the C=C bond in buta-1,3–diene?

A. -248 - (2 x 436) + (2 x 346) + (4 x 414)

B. -124 - 436 + 346 + (2 x 414)

C. (2 x 346) + (4 x 414) + 248 - (2 x 436)

D. 346 + (2 x 414) + 124 - 436

[1 mark]

Question 5

The equations to form methane and propane from their gaseous atoms are:

$$C(g) + 4H(g) \rightarrow CH_4(g) \qquad \Delta H_r = -1656\ kJ\ mol^{-1}$$

$$3C(g) + 8H(g) \rightarrow C_3H_8(g) \qquad \Delta H_r = -4004\ kJ\ mol^{-1}$$

What is the bond enthalpy of a C-C bond?

A. $\frac{-4004 + 2 \times (1656)}{3}$

B. 2002 - 1656

C. 1656 - 2002

D. $\frac{-4004 - 2 \times (1656)}{3}$

[1 mark]

Question 6

Ultraviolet radiation is split into three regions:

- UV A (wavelength 400 - 320 nm)
- UV B (wavelength 320 - 280 nm)
- UV C (wavelength < 280 nm)

High energy photons are present in the solar spectrum at high altitude. The maximum wavelength of a photon that has enough energy to break the O=O bond in oxygen is 240 nm, which is in the UV C region of ultraviolet radiation..

The energy per mole required to break an O=O bond can be calculated using the following equation:

$$\frac{Bond\ energy\ per\ mole}{Avogadro's\ constant} = \text{Energy per bond}$$

Using the supplementary equations $c = \nu\lambda$ and $E = h\nu$, which is the correct calculation to determine the bond energy of an O=O in kJ mol^{-1}?

Avogadro's constant = 6.02×10^{23}

Planck's constant = 6.63×10^{-34} J s

Speed of light = 3.00×10^{8} m s^{-1}

A. $\frac{6.63 \times 3.00 \times 6.02 \times 10}{2.4}$

B. $\frac{6.63 \times 3.00 \times 6.02 \times 10^{4}}{2.4}$

C. $\frac{6.63 \times 3.00 \times 6.02 \times 10^{-3}}{2.4}$

D. $\frac{6.02 \times 2.4 \times 10^{42}}{6.63 \times 3.00}$

[1 mark]

Question 7

Which of the following statements about the average bond enthalpy of the halogens are correct?

I. Fluorine has the highest average bond enthalpy
II. Average bond enthalpy generally decreases as the size of the atoms increases
III. In general, increased shielding results in a lower bond enthalpy

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

[1 mark]

Question 8

What is the correct order to show the decreasing strength of the F-H, N-H and O-H bonds?

A. N-H > O-H > F-H

B. O-H > N-H > F-H

C. F-H > N-H > O-H

D. F-H > O-H > N-H

[1 mark]

Question 9

Water has two different bond enthalpies for the two O-H bonds that it contains:

$$H_2O\,(g) \rightarrow H\,(g) + OH\,(g) \qquad \Delta H = +502\ kJ\ mol^{-1}$$

$$OH\,(g) \rightarrow H\,(g) + O\,(g) \qquad \Delta H = +427\ kJ\ mol^{-1}$$

The average O-H bond enthalpy from an accepted data table is 463 kJ mol^{-1}.

Which calculation correctly shows the percentage difference between the average O-H bond enthalpy of water and the data table average bond enthalpy value?

A. $100 \div \left(\frac{502 + 427}{2 \times 463} - 1 \right)$

B. $100 \times \left(\frac{502 + 427}{2 \times 463} - 1 \right)$

C. $100 \times \left(\frac{2 \times 463}{502 + 427} - 1 \right)$

D. $100 \times \left(\frac{502 + 427}{2 \times 436} - 1 \right)$

[1 mark]

Question 10

Some of the reactions involved in the formation and depletion of ozone are:

I. $O_2 \rightarrow 2O^{\bullet}$
II. $O_2 + O^{\bullet} \rightarrow O_3$
III. $O_3 + O^{\bullet} \rightarrow 2O_2$

Which reactions are exothermic?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

[1 mark]