SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 The first five ionization energies of an element, **X**, are

578, 1817, 2745, 11578 and 14831 kJ mol^{-1}, respectively.

In which group of the Periodic Table is **X** found?

☒ **A** 1

☒ **B** 2

☒ **C** 3

☒ **D** 4

(Total for Question 1 = 1 mark)

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2 Which of the following oxides would be expected to have the most exothermic lattice energy?

☒ **A** Na_2O

☒ **B** MgO

☒ **C** CaO

☒ **D** K_2O

(Total for Question 2 = 1 mark)

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3 In which of the following compounds is the **anion** most polarized?

☒ **A** LiF

☒ **B** LiI

☒ **C** KF

☒ **D** KI

(Total for Question 3 = 1 mark)

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4 In the Born-Haber cycle for potassium iodide, which of the following steps is **exothermic**?

☒ **A** $K(s) \rightarrow K(g)$

☒ **B** $K(g) \rightarrow K^+(g) + e^-$

☒ **C** $\frac{1}{2}I_2(s) \rightarrow I(g)$

☒ **D** $I(g) + e^- \rightarrow I^-(g)$

(Total for Question 4 = 1 mark)

5 Which of the following represents a pair of isotopes?

☒ **A** $^{14}_{6}C$ and $^{14}_{7}N$

☒ **B** $^{32}_{16}S$ and $^{32}_{16}S^{2-}$

☒ **C** O_2 and O_3

☒ **D** $^{206}_{82}Pb$ and $^{208}_{82}Pb$

(Total for Question 5 = 1 mark)

6 Which of the following equations represents the **second** ionization energy of chlorine?

☒ **A** $Cl^+(g) \rightarrow Cl^{2+}(g) + e^-$

☒ **B** $Cl(g) \rightarrow Cl^{2+}(g) + 2e^-$

☒ **C** $Cl(g) \rightarrow Cl^{2-}(g) - 2e^-$

☒ **D** $Cl^-(g) \rightarrow Cl^{2-}(g) - e^-$

(Total for Question 6 = 1 mark)

7 For Period 3 of the Periodic Table, from sodium to argon, what is the trend in the melting temperatures of the elements?

☒ **A** A steady decrease

☒ **B** A steady increase

☒ **C** A decrease to silicon then an increase

☒ **D** An increase to silicon then a decrease

(Total for Question 7 = 1 mark)

8 Given the following information

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

the mean bond enthalpy for the C—H bond in methane is

☒ **A** $+Q$

☒ **B** $+Q/4$

☒ **C** $-Q$

☒ **D** $-Q/4$

(Total for Question 8 = 1 mark)

9 Consider the following information:

Bond	Bond enthalpy / kJ mol^{-1}
H—H	+436
I—I	+151
H—I	+299

For the reaction

$$H_2(g) + I_2(g) \rightarrow 2HI(g)$$

the enthalpy change, in kJ mol^{-1}, is

☒ **A** +288

☒ **B** +144

☒ **C** −11

☒ **D** −5.5

(Total for Question 9 = 1 mark)

10 The equation for the complete combustion of butanone, $C_2H_5COCH_3$, is

$$C_2H_5COCH_3(l) + 5\frac{1}{2}O_2(g) \rightarrow 4CO_2(g) + 4H_2O(l) \qquad \Delta H^{\ominus} = -2440 \text{ kJ mol}^{-1}$$

Substance	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
$CO_2(g)$	–394
$H_2O(l)$	–286

From the above data, the standard enthalpy change of formation of butanone, in kJ mol^{-1}, is

☒ **A** –280

☒ **B** +280

☒ **C** –1760

☒ **D** +1760

(Total for Question 10 = 1 mark)

11 A compound was found to contain 2.8 g of nitrogen and 8.0 g of oxygen.

What is the empirical formula of the compound?

Use the Periodic Table as a source of data.

☒ **A** NO

☒ **B** NO_2

☒ **C** N_2O_3

☒ **D** N_2O_5

(Total for Question 11 = 1 mark)

12 What is the total number of **atoms** in 1.8 g of water, H_2O?

DATA
- The molar mass of H_2O is 18 g mol^{-1}
- The Avogadro Constant is 6.0×10^{23} mol^{-1}

☒ **A** 6.0×10^{22}

☒ **B** 6.0×10^{23}

☒ **C** 1.8×10^{23}

☒ **D** 1.8×10^{24}

(Total for Question 12 = 1 mark)

13 Phosphorus(V) chloride, PCl_5, reacts with water according to the equation

$$PCl_5(s) + 4H_2O(l) \rightarrow H_3PO_4(aq) + 5HCl(aq)$$

If 1.04 g of phosphorus pentachloride (molar mass = 208 g mol^{-1}) is reacted completely with water and the solution made up to 1 dm^3, the concentration of the hydrochloric acid in mol dm^{-3} is

☒ **A** 0.001

☒ **B** 0.005

☒ **C** 0.025

☒ **D** 0.250

(Total for Question 13 = 1 mark)

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14 A sample of sodium chlorate(V), $NaClO_3$, was heated and 120 cm^3 of oxygen gas was collected.

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

Calculate the number of moles of sodium chlorate(V) that were decomposed in the above reaction.

[Molar volume of a gas under the conditions of the experiment = 24000 cm^3 mol^{-1}]

☒ **A** 2.50×10^{-3}

☒ **B** 3.33×10^{-3}

☒ **C** 5.00×10^{-3}

☒ **D** 7.50×10^{-3}

(Total for Question 14 = 1 mark)

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15 In the ethene molecule, the C=C double bond is made up of

☒ **A** two sigma bonds.

☒ **B** one pi bond.

☒ **C** two pi bonds.

☒ **D** one sigma bond and one pi bond.

(Total for Question 15 = 1 mark)

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16 3.0 dm^3 of sulfur dioxide reacts with 1.5 dm^3 of oxygen, under suitable conditions, according to the equation below.

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$

What is the maximum volume of sulfur trioxide that can be formed in the above reaction?

[The volumes of the gases are measured at the same temperature and pressure.]

☒ **A** 6.0 dm^3

☒ **B** 4.5 dm^3

☒ **C** 3.0 dm^3

☒ **D** 1.5 dm^3

(Total for Question 16 = 1 mark)

17 Which of the following alkenes exhibits *E/Z* isomerism?

☒ **A** But-1-ene

☒ **B** But-2-ene

☒ **C** 2-Methylpropene

☒ **D** Propene

(Total for Question 17 = 1 mark)

18 An electrophile is **defined** as a species that

☒ **A** is an electron pair acceptor.

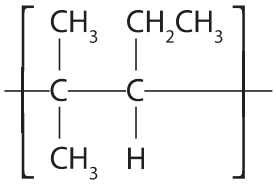
☒ **B** is an electron pair donor.

☒ **C** has a negative charge.

☒ **D** has a positive charge.

(Total for Question 18 = 1 mark)

19 The repeat unit of a polymer is shown below.



The systematic name of the alkene monomer that forms this polymer is

☒ **A** 2-methyl-3-ethylpropene

☒ **B** 2-methylpent-2-ene

☒ **C** 2-methylpent-3-ene

☒ **D** 4-methylpent-2-ene

(Total for Question 19 = 1 mark)

20 Cracking crude oil

☒ **A** separates the mixture into pure compounds.

☒ **B** separates the mixture into a number of fractions.

☒ **C** separates saturated compounds from unsaturated ones.

☒ **D** decreases the average number of carbon atoms per molecule.

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which of the following could be used to oxidize ethanol to ethanoic acid?

☒ **A** Concentrated H_2SO_4

☒ **B** $H^+/Cr_2O_7^{2-}$

☒ **C** H^+/Cr^{3+}

☒ **D** Concentrated NaOH solution

(Total for Question 1 = 1 mark)

2 The term "reflux" is best described as

☒ **A** continuous evaporation and condensation.

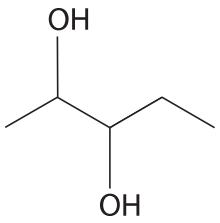
☒ **B** heating to evaporation and separation.

☒ **C** heating under reduced pressure and separation.

☒ **D** constant boiling.

(Total for Question 2 = 1 mark)

3 The alcohol shown below can be classified as



☒ **A** just primary.

☒ **B** primary and secondary.

☒ **C** just secondary.

☒ **D** secondary and tertiary.

(Total for Question 3 = 1 mark)

4

$$C_2H_5Br + NaOH \rightarrow C_2H_4 + NaBr + H_2O$$

This reaction is an example of

☒ **A** addition.

☒ **B** elimination.

☒ **C** hydrolysis.

☒ **D** oxidation.

(Total for Question 4 = 1 mark)

5 Which of the following is **not** a greenhouse gas?

☒ **A** H_2O

☒ **B** NO

☒ **C** CH_4

☒ **D** O_2

(Total for Question 5 = 1 mark)

6 Which type of radiation is absorbed by molecules and results in the greenhouse effect?

☒ **A** Infrared

☒ **B** Microwave

☒ **C** Ultraviolet

☒ **D** X-ray

(Total for Question 6 = 1 mark)

7 It is important to lower the level of carbon dioxide in the atmosphere because of concerns over which environmental problem?

☒ **A** Acid rain

☒ **B** Global warming

☒ **C** Non-biodegradability

☒ **D** Ozone depletion

(Total for Question 7 = 1 mark)

8 The meaning of homolytic fission is

☒ **A** bond-breaking to form two free radicals.

☒ **B** bond-making to form two free radicals.

☒ **C** bond-breaking to form a cation and an anion.

☒ **D** bond-making to form a cation and an anion.

(Total for Question 8 = 1 mark)

9 What are the strongest forces between molecules of hydrogen fluoride, HF?

☒ **A** Dipole-dipole forces.

☒ **B** Hydrogen bonds.

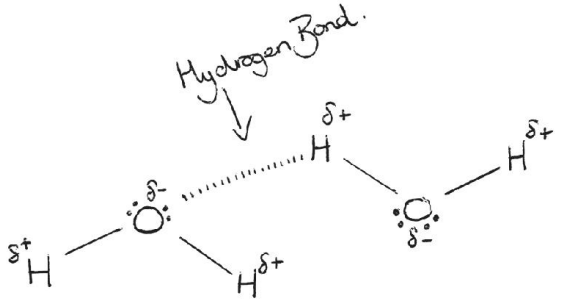
☒ **C** Ionic interactions.

☒ **D** London forces.

(Total for Question 9 = 1 mark)

10 The diagram below is taken from a student's examination paper. It shows the hydrogen bonding between two water molecules.

Identify the error in the diagram.



☒ **A** The H—O—H bond angle within each water molecule should be 90°.

☒ **B** There should only be one lone pair of electrons on each oxygen atom.

☒ **C** The O—H—O bond angle between the water molecules should be 180°.

☒ **D** The hydrogen atoms should be ∂^- and the oxygen atoms should be ∂^+.

(Total for Question 10 = 1 mark)

11 The boiling temperatures from methane to propane increase because

- ☒ **A** the number of ions increases, so there are stronger electrostatic attractions.
- ☒ **B** the covalent bonds are getting stronger, so require more energy to break.
- ☒ **C** there are more covalent bonds, so more energy is needed to break them.
- ☒ **D** the number of electrons increases, so there are stronger London forces.

(Total for Question 11 = 1 mark)

12 In a chemical reaction, which of the following factors increases the proportion of particles that have sufficient energy to react?

- ☒ **A** A decrease in concentration
- ☒ **B** An increase in concentration
- ☒ **C** A decrease in temperature
- ☒ **D** An increase in temperature

(Total for Question 12 = 1 mark)

13 A 'greener' chemical process will be one that

- ☒ **A** uses energy less efficiently.
- ☒ **B** forms a non-polluting waste product.
- ☒ **C** produces significant amounts of waste.
- ☒ **D** makes use of non-renewable resources.

(Total for Question 13 = 1 mark)

14 Which of the following **cannot** alter the position of a chemical equilibrium?

- ☒ **A** Increasing the amount of catalyst
- ☒ **B** Increasing the reactant concentration
- ☒ **C** Increasing the temperature
- ☒ **D** Increasing the total pressure

(Total for Question 14 = 1 mark)

15 $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H = -91 \text{ kJ mol}^{-1}$

The conditions which would produce the greatest yield of methanol are

☒ **A** high pressure and high temperature.

☒ **B** high pressure and low temperature.

☒ **C** low pressure and low temperature.

☒ **D** low pressure and high temperature.

(Total for Question 15 = 1 mark)

16 What is the oxidation number of chlorine in Cl_2O_7?

☒ **A** –1

☒ **B** +1

☒ **C** –7

☒ **D** +7

(Total for Question 16 = 1 mark)

17 The concentration of a solution of potassium iodate(V) can be determined by the liberation of iodine, followed by titration with sodium thiosulfate.

A suitable indicator is

☒ **A** methyl orange.

☒ **B** phenolphthalein.

☒ **C** starch.

☒ **D** universal indicator.

(Total for Question 17 = 1 mark)

18 The thermite reaction, shown below, is a useful industrial process.

$$Fe_2O_3(s) + 2Al(s) \rightarrow 2Fe(l) + Al_2O_3(s)$$

The iron in this reaction undergoes

☒ **A** disproportionation.

☒ **B** oxidation.

☒ **C** redox.

☒ **D** reduction.

(Total for Question 18 = 1 mark)

19 Which of the following molecules has a linear shape and bond angles of 180°?

☒ **A** CH_4

☒ **B** H_2O

☒ **C** CO_2

☒ **D** SF_6

(Total for Question 19 = 1 mark)

20 What would be the experimental observations if chlorine gas was bubbled through potassium iodide solution, followed by the addition of cyclohexane?

☒ **A** The solution turns brown, then two layers are produced and the top layer is purple.

☒ **B** A white precipitate is formed, which then dissolves to leave a colourless solution.

☒ **C** Bubbles of gas are seen and then a brown precipitate is formed.

☒ **D** The solution remains colourless, and then two layers are seen with the bottom layer being brown.

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

21 This is a question about Group 2 compounds.

Limewater is a solution of calcium hydroxide, commonly used in the identification of carbon dioxide gas. Since calcium hydroxide is only sparingly soluble in water, technicians often make the solution by adding an excess of the solid calcium hydroxide to the required volume of deionised water, shaking the container and then leaving the mixture to settle. In this way, a saturated solution is produced but it can be of variable concentration.

Two students were each given a sample of limewater, from the same batch, in order to determine its concentration. Using 50.0 cm^3 portions of the limewater, they carried out titrations using 0.100 mol dm^{-3} hydrochloric acid. One of the students obtained the following results:

Titration	Trial	1	2
Final Volume /cm^3	14.50	28.60	42.70
Initial Volume /cm^3	0.00	14.50	28.60
Volume Added /cm^3	14.50	14.10	14.10

The student decided that the mean titre was 14.10 cm^3

The equation for the reaction is:

$$Ca(OH)_2(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$$

(a) (i) Calculate the number of moles of hydrochloric acid that reacted.

(1)

(ii) Calculate the number of moles of calcium hydroxide, $Ca(OH)_2$, that reacted with the acid.

(1)

(iii) Calculate the concentration of $Ca(OH)_2$, in mol dm^{-3}, in this sample of limewater.

(1)

(iv) Calculate the concentration of $Ca(OH)_2$, in g dm^{-3}, in this sample of limewater. Use the Periodic Table as a source of data.

(2)

(v) This student did not include the trial value when calculating the mean titre. Explain why.

(1)

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(vi) The second student obtained a different mean titre value for the experiment and thought that this difference may be due to the use of a faulty pipette.

Suggest a simple method, involving distilled water and a balance, by which the accuracy of the pipette in measuring out exactly 50.0 cm^3 could be checked.

(2)

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