ALEXANDER ROAD HIGH SCHOOL

June 2022 | **PHYSICAL SCIENCES JUNE PAPER 2** | 2 HOURS

JA | **GRADE 11** | TOTAL = 100

Instructions:

- The question paper consists of 7 questions.
- Answer all the questions.
- Answer section A on the answer sheet provided AND section B on folio sheets.
- A non-programmable calculator may be used.
- Number the answers correctly according to the numbering system.
- Round off to at least two (2) decimal places where necessary.
- A periodic table has been provided on the back of the answer sheet.
- A formula sheet has been provided at the end of the question paper.

SECTION A

(answer on the answer sheet)

QUESTION 1:

Four possible options are provided as answers to the following questions. Each question has only one correct answer. Choose the correct answer and write the letter (A – D) next to the relevant question number (1.1 – 1.10) on the answer sheet.

1.1 The definition of *electronegativity* is…

A. a covalent bond in which the electron density is shared unequally between the two atoms resulting in partial charges on each atom.

B. a measure of the tendency of an atom in a molecule to attract bonding electrons.

C. the three atoms nitrogen, oxygen and fluorine (NOF).

D. the overlapping of half-filled orbitals resulting in the sharing of electrons and the formation of a molecule.

1.2 Which ONE of the following molecules has the LARGEST bond energy?

A. H_2

B. N_2

C. O_2

D. F_2

1.3 Which ONE of the following substances has the LOWEST melting point?

A. Ice

B. Chlorine

C. Methane (CH_4)

D. Potassium

1.4 Which ONE of the following substances experiences ION-DIPOLE forces?

A. $CuSO_4$ (s)

B. Cu (s)

C. Cu^{2+} (aq)

D. H_2O (ℓ)

1.5 *Activation energy* is defined as…

A. the unstable (energetic) transition state from reactants to products.

B. the energy needed to break one mole of a compound's molecules into separate atoms.

C. the energy absorbed at the start of a reaction to break existing bonds.

D. the minimum energy needed for a reaction to take place.

1.6 The heat of reaction (ΔH) for a particular reaction is positive. Which ONE of the following statements is FALSE?

A. More energy was released than absorbed.

B. More energy was absorbed than released.

C. Energy was released as the products formed.

D. The reaction is an endothermic reaction.

1.7 Which ONE of the following is NOT a reason for percentage yield always being less than 100% in any chemical reaction?

A. Impurities in the reactants
B. The presence of side reactions
C. The destruction of reactant atoms
D. Practical losses of the product

1.8 Which ONE of the following has the GREATEST number of particles?

A. 3,5 mol copper (Cu)
B. 3,5 mol caffeine ($C_8H_{10}N_4O_2$)
C. 78,4 dm^3 carbon dioxide at STP
D. 0,3 kg table salt

1.9 0,4 mol of ammonia (NH_3) is produced from the reaction of 0,25 mol nitrogen with excess hydrogen according to the following balanced chemical equation:

$$N_2\,(g) + 3\,H_2\,(g) \rightarrow 2\,NH_3\,(g)$$

The percentage yield for the reaction is…

A. 80%
B. 62,5%
C. 31,25%
D. 100%

1.10 0,25 mol aluminium burns in 0,3 mol oxygen to form aluminium oxide according to the following balanced chemical equation:

$$2\,A\ell\,(s) + 3\,O_2\,(g) \rightarrow 2\,A\ell_2O_3\,(s)$$

Which ONE of the following statements is TRUE?

A. Aluminium is the limiting reactant and 0,075 mol O_2 is leftover at the end.
B. Aluminium is the limiting reactant and 0,1 mol O_2 is leftover at the end.
C. Oxygen is the limiting reactant and 0,125 mol Al is leftover at the end.
D. Oxygen is the limiting reactant and 0,05 mol Al is leftover at the end.

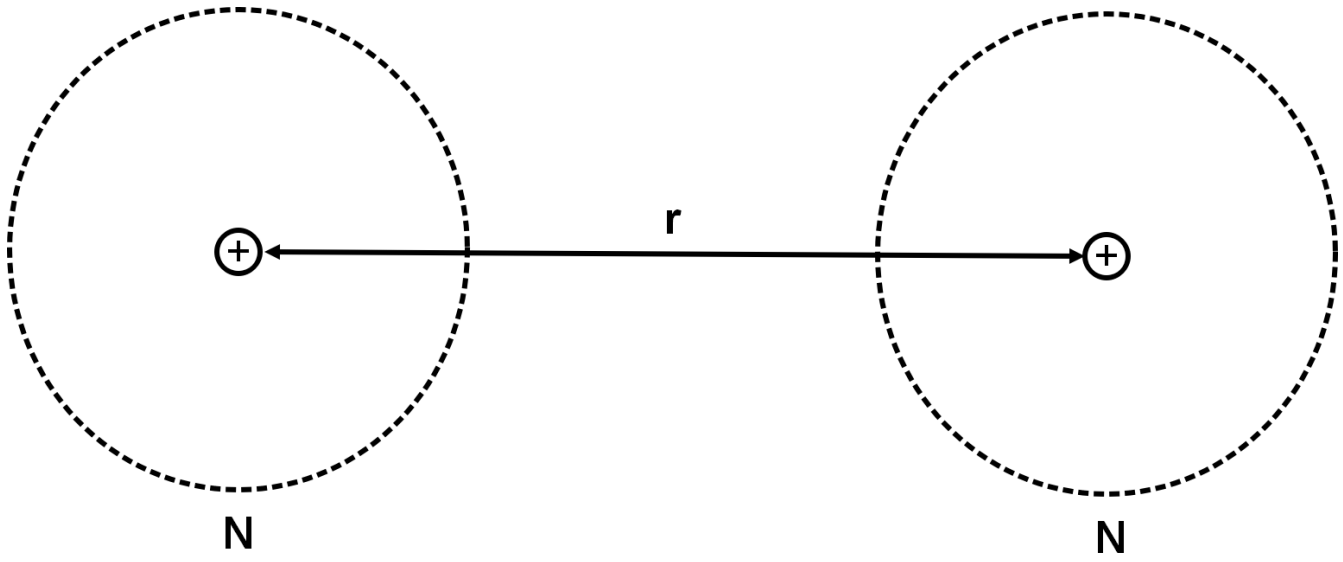
TOTAL SECTION A = [20]

SECTION B

(answer on folio paper)

QUESTION 2:

Siya gradually decreases the internuclear distance (**r**) between two nitrogen atoms whilst constantly monitoring the potential energy (**E**) of the system.



Siya discovers the system reaches a minimum potential energy of -946 kJ when the nitrogen atoms are 109 pm apart.

2.1 Define the term *chemical bond*. (2)

2.2 Identify the independent variable in this experiment. (1)

2.3 Sketch a graph of E vs. r for this experiment.
Clearly label any given values on the graph. (3)

[6]

QUESTION 3:

Consider the following list of molecules:

Name of Molecule	Molecular Formula
Carbon disulphide	CS_2
Oxygen difluoride	OF_2
Ammonium ion	NH_4^+

3.1 Define the term *bonding pair*. (2)

3.2.1 Draw the Lewis diagram of carbon disulphide. (2)

3.2.2 How many bonding pairs are there in one molecule of carbon disulphide? (1)

3.2.3 Does carbon disulphide have POLAR or NON-POLAR bonds?
Justify your answer with a calculation. (2)

3.3 Draw the Couper notation of oxygen difluoride. **Indicate any partial charges.** (3)

3.4 Is oxygen difluoride a POLAR or NON-POLAR molecule? **Explain.** (2)

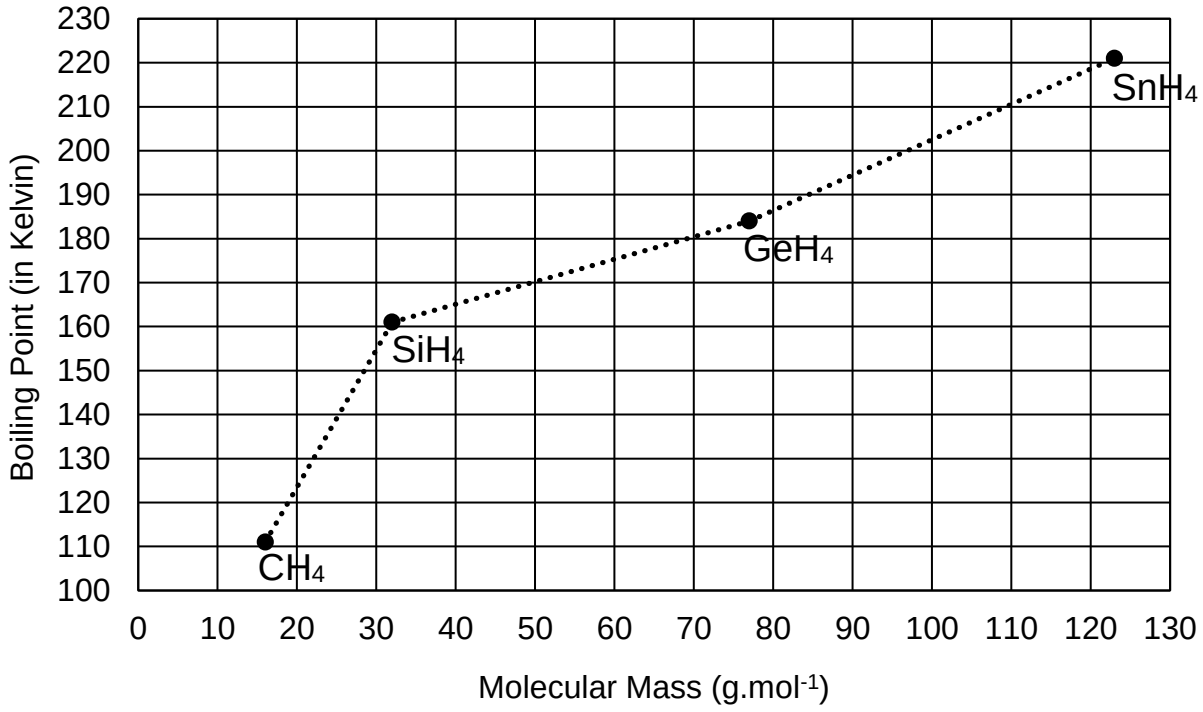
3.5.1 Use Lewis diagrams to represent the formation of the ammonium ion from ammonia (NH_3) and the hydrogen ion (H^+). (3)

3.5.2 What is the name of the bond between NH_3 and H^+? (1)

[16]

QUESTION 4:

A graph of boiling point vs. molecular mass for the group IV hydrides (CH_4, SiH_4, GeH_4 and SnH_4) is given below.



4.1 Define the term *vapour pressure*. (2)

4.2 Based on information contained in the graph, what is the relationship (if any) between the molecular mass and the boiling point? (2)

4.3 What phase is the group IV hydrides in at room temperature (298 K)? (1)

4.4 Which group IV hydride has the lowest vapour pressure?
Use the graph to explain your answer. (3)

4.5 Explain why SiH_4 has a lower boiling point than GeH_4. (3)

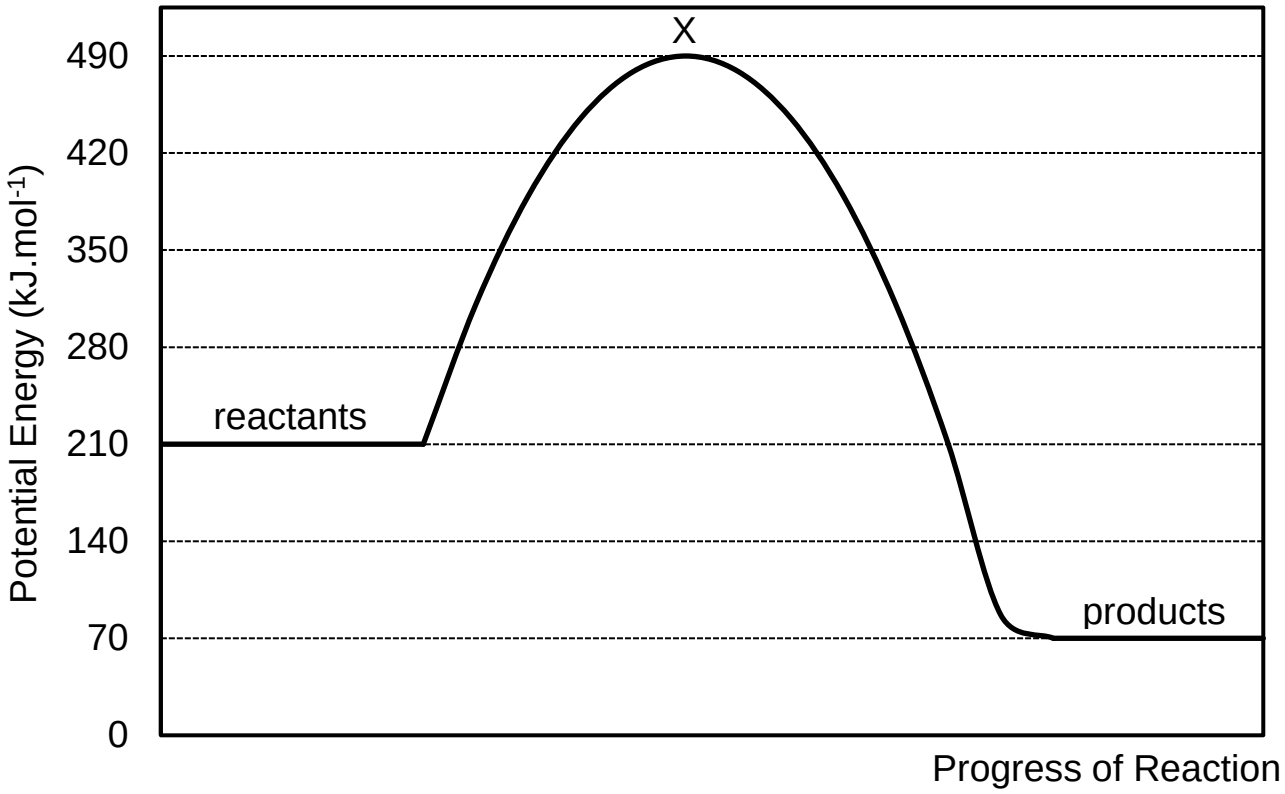
4.6 A manufacturer of methane (CH_4) wishes to dissolve the methane as it makes it easier to transport. Which solvent would work better: carbon tetrachloride ($CC\ell_4$) or water? **Briefly explain.** (2)

4.7 The boiling point of ammonia (NH_3) is 240 K. Explain why NH_3 has a much higher boiling point than CH_4 even though their molar masses are very similar. (3)

[16]

QUESTION 5:

Consider the following potential energy diagram for a particular reaction.



5.1 Define the term *heat of reaction*. (2)

5.2 Provide a label for X. (1)

5.3 Is the reaction ENDOTHERMIC or EXOTHERMIC?
Explain using the graph. (2)

5.4 Use the diagram to calculate:

5.4.1 The activation energy (E_A). (2)

5.4.2 The heat of reaction (ΔH). (2)

5.4.3 The total energy released by the formation of the products. (2)

[11]

QUESTION 6:

The engine of a Formula 1 (F1) racing car uses the heat generated by a reaction between the fuel and oxygen in the surrounding air to propel the car around the racing track. The fuel is a liquid mixture of various hydrocarbon compounds. Consider the following **incomplete** equation showing the reaction of one particular hydrocarbon (C_xH_y) found inside the fuel used in an F1 car with oxygen:

$$C_xH_y + O_2\,(g) \rightarrow CO_2\,(g) + H_2O\,(l)$$

6.1.1 What is the *empirical formula* of a compound? (2)

6.1.2 Sergio, a chemical engineer working for the Red Bull F1 Team, determines the hydrocarbon (C_xH_y) consists of 84,21% carbon and 15,79% hydrogen. Determine the empirical formula of the hydrocarbon. (3)

6.2 Assume the molecular formula of the hydrocarbon is $\mathbf{C_8H_{18}}$.

6.2.1 After some experimentation, Sergio discovers that the engine performs best when the concentration of C_8H_{18} in the fuel is 0,25 $mol.dm^{-3}$. Calculate the mass of C_8H_{18} which Sergio needs to obtain this concentration if the fuel tank of an F1 car takes 140 ℓ of fuel. (4)

6.2.2 Greta, an environmental activist, is concerned with the amount of CO_2 released into the atmosphere by F1 cars. She does some research online and discovers:

- Approximately 400 dm^3 of air pass through the engine every second.
- Approximately 21% of air is oxygen.

Use the information above to calculate the number of CO_2 molecules released into the atmosphere per second, given the molar volume is 26 $dm^3.mol^{-1}$.
(Ignore all other hydrocarbons present in the fuel). (8)

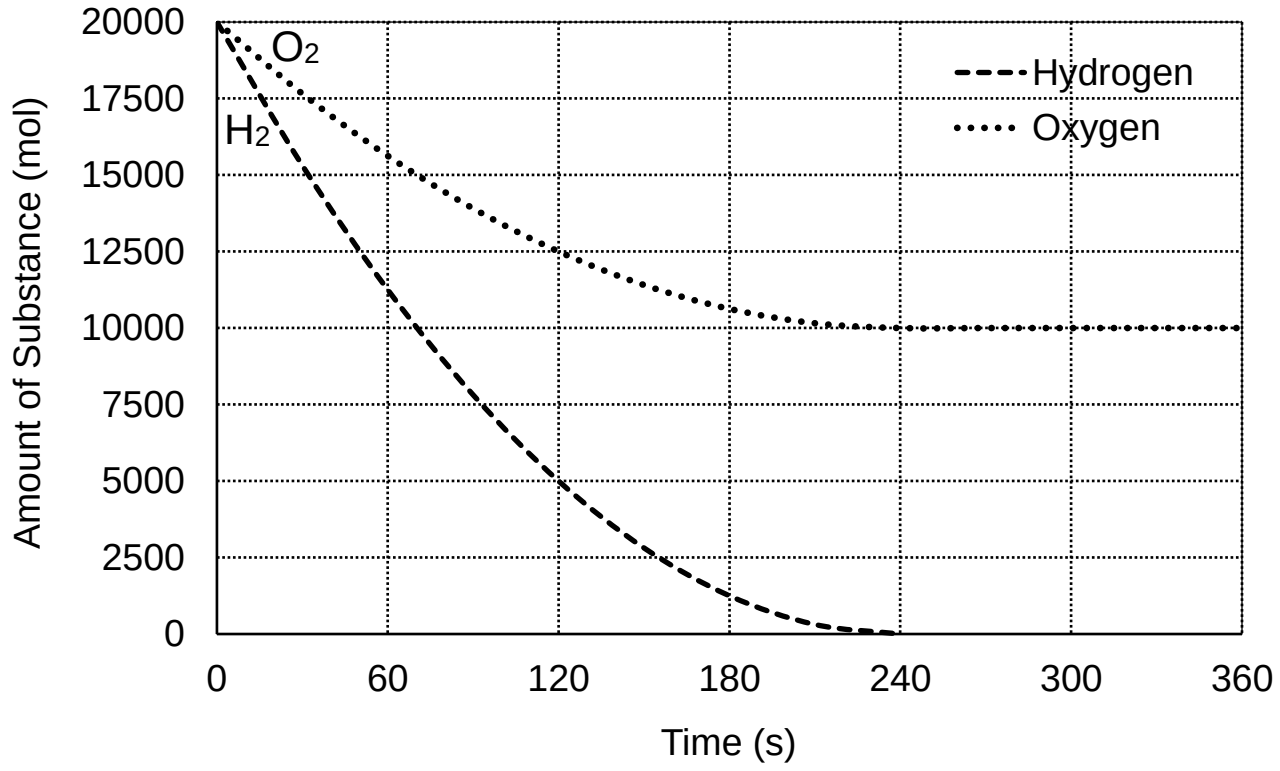
[17]

QUESTION 7:

The fuel used to launch rockets into space consists of hydrogen and oxygen which react to form water according to the following balanced chemical equation:

$$2\ H_2\ (g) \ + \ O_2\ (g) \ \rightarrow \ 2\ H_2O\ (g) \qquad \Delta H = -188\ kJ.mol^{-1}$$

Buzz, an engineer at NASA, wishes to find the mix of hydrogen and oxygen that will make the most efficient rocket fuel. He begins by mixing equal amounts of hydrogen and oxygen and measures the change in the amounts of each as the rocket launches into space. The following graph shows the results Buzz obtained:



7.1 Explain what is meant by the term *limiting reactant*. (1)

7.2 Using the graph:

7.2.1 Write down the FORMULA of the limiting reactant. (1)

7.2.2 Calculate the mass of water released. (3)

7.2.3 Calculate the volume of the excess reactant leftover once the reaction is complete if the rocket is at STP. (3)

7.3 Buzz concludes that mixing equal amounts of hydrogen and oxygen does not produce the most efficient fuel since there is some leftover (i.e. wasted) reactant. What is the best ratio in which to mix the hydrogen and oxygen? (1)

7.4 Why do environmental activists like Greta (from question 6.2.2) think rocket fuel is "clean" but F1 fuel (from question 6) is "dirty" (i.e. pollutes the environment)? (2)

7.5 In a separate experiment, Buzz aims to determine the amount of energy released by rocket fuel. He mixes 250 kg of oxygen with excess hydrogen. Calculate the amount of energy released. (3)

[14]

TOTAL SECTION B = [80]

Formula Sheet

Physical Constants:

Name	Symbol	Value
Avogadro's constant	N_A	$6{,}02 \times 10^{23}$ mol^{-1}
Standard pressure	p^θ	$1{,}013 \times 10^5$ Pa
Molar gas volume at STP	V_m	22,4 dm^3.mol^{-1}
Standard temperature	T^θ	273 K

Formulae:

CHEMISTRY

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$n = \frac{V}{V_m}$	$c = \frac{n}{V}$ or $c = \frac{m}{MV}$