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ST JOHN'S COLLEGE

Upper V Physical Science

Paper 2 - Chemistry

Examiner: G Hingle

Time: 3 hours

Moderator: P Wright

Total: 200

August 2019

Name: _____

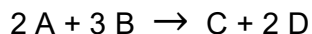
Please circle your teacher's initials :

KMcN	JN	PW	CH	NS	GH
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- 1) The paper consists of 16 pages of questions. There is a separate 1 page answer sheet. A 3 page data sheet is also provided separately.
- 2) Answer Question 1 on the answer sheet provided in the answer book.
- 3) Questions 2 – 9 must be answered in the answer book. Start a new question on a new page in the answer book.
- 4) Calculators may be used.
- 5) Round off to 2 decimal places where appropriate.

Question 1 – Multiple Choice – Please answer on the answer sheet provided.

- 1.1 The rate of removal of A in the hypothetical reaction below is $x \text{ mol}\cdot\text{s}^{-1}$.



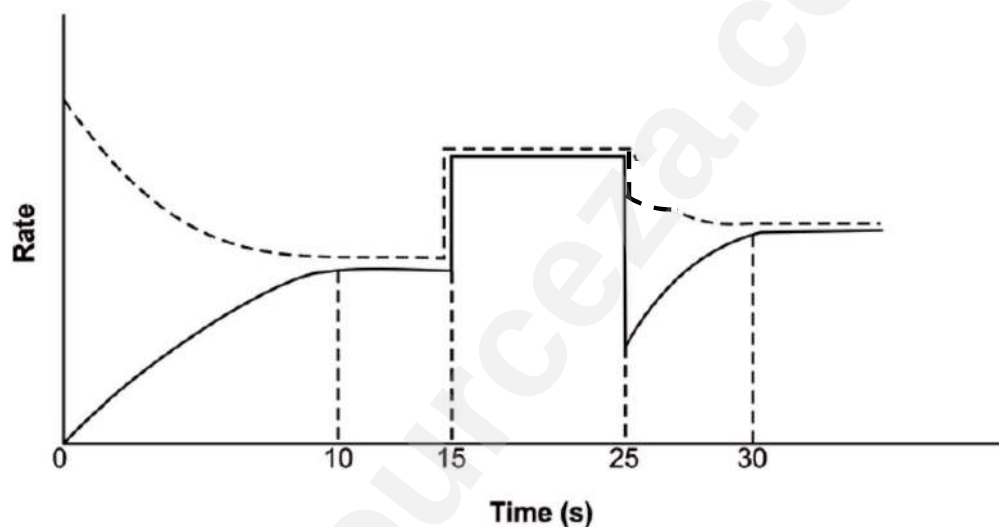
What is the rate of appearance of C in $\text{mol}\cdot\text{s}^{-1}$?

- A $2x$
- B x
- C $\frac{1}{2}x$
- D $\frac{2}{3}x$
- 1.2 A salt can be defined as a substance in which the hydrogen of
- A an acid has been replaced by an anion.
- B an acid has been replaced by a cation.
- C a base has been replaced by an anion
- D a base has been replaced by a cation.
- 1.3 A system is at equilibrium. If the system is cooled, which of the following will change?
- I rates of the forward and reverse reactions
- II K_c
- III equilibrium position
- A I only
- B I and II only
- C I and III only
- D I, II and III

- 1.4 A hypothetical chemical reaction in a closed container is represented by the following chemical equation.



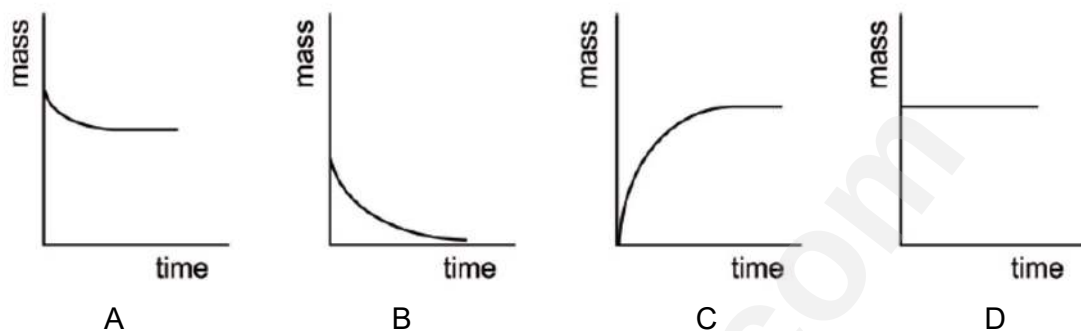
The graph below represents the rates of the forward and reverse reactions plotted as a function of time.



Which one of the following statements could correctly describe the factors that caused the change in reaction rate.

	Disturbance at 15 s	Disturbance at 25 s
A	Surface area of A was increased	The pressure of the system was increased.
B	A catalyst was added.	The temperature was decreased.
C	The temperature of the system was increased.	The surface area of A was decreased.
D	The pressure of the system was decreased.	The temperature of the system was increased.

- 1.5 Which of the following graphs shows the change in mass of a catalyst during the course of a reaction?



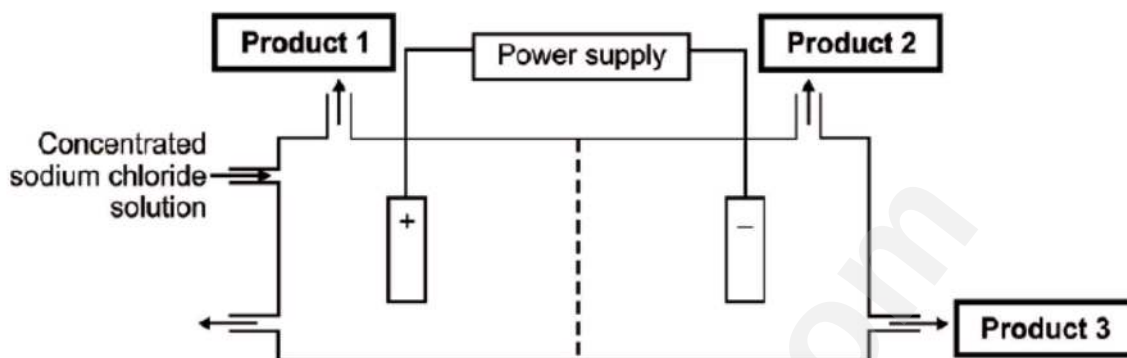
- 1.6 Consider the list of metals below. Identify the metal that will be able to reduce $\text{Cd}^{2+}(\text{aq})$ to $\text{Cd}(\text{s})$ but which will not reduce $\text{Mn}^{2+}(\text{aq})$ to $\text{Mn}(\text{s})$.

- A Zinc
- B Magnesium
- C Nickel
- D Silver

- 1.7 The aqueous solution with the highest conductivity is

- A $0,1 \text{ mol} \cdot \text{dm}^{-3} \text{ HF}$
- B $0,2 \text{ mol} \cdot \text{dm}^{-3} \text{ HCl}$
- C $0,3 \text{ mol} \cdot \text{dm}^{-3} \text{ NH}_4\text{OH}$
- D $0,2 \text{ mol} \cdot \text{dm}^{-3} \text{ H}_3\text{PO}_4$

1.8 A typical membrane cell is illustrated below.



Which letter correctly describes the products that form?

	Product 1	Product 2	Product 3
A	H_2 (g)	Cl_2 (g)	NaOH (aq)
B	Cl_2 (g)	H_2 (g)	Na (s)
C	Cl_2 (g)	H_2 (g)	NaCl (aq)
D	Cl_2 (g)	H_2 (g)	NaOH (aq)

1.9 Hydrohalogenation reactions could involve

- A the substitution of HBr in an alcohol.
- B the addition of H_2O to an alkene.
- C the addition of HCl to an alkene.
- D the addition of HI to an alcohol.

1.10 Which of the following molecules has the highest boiling point?

- A hexane
- B propane
- C 2,3 – dimethylbutane
- D propene

[20]

Question 2 – Structure and Bonding

- 2.1 Use only substances from the list below when answering Questions 2.1.1 to 2.1.8. The phase symbols represent the physical state of each of the substances at room temperature.

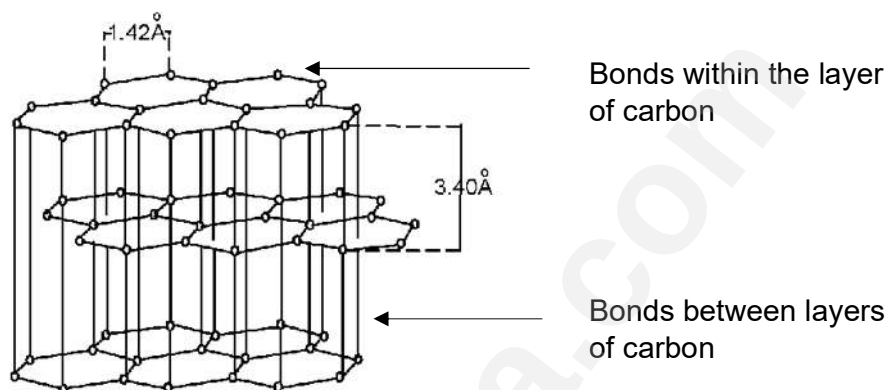
Graphite (s) NH₃ (g) NaF (s) C₈H₁₈ (l)

Ar (g) Zn (s) MgSO₄ (s) F₂ (g)

For each of the questions that follow – select ONE of the substances from the list. Substances may be used more than once or not at all.

- 2.1.1 Substance that can conduct electricity in both solid and liquid phases. (1)
- 2.1.2 Substance that has giant covalent network structure. (1)
- 2.1.3 **Element** with pure covalent bonds. (1)
- 2.1.4 Substance that has non-polar molecules despite the presence of polar covalent bonds within the molecule. (1)
- 2.1.5 Substance that consists of individual atoms that interact through London forces. (1)
- 2.1.6 Substance that consists of an ionic giant structure. (1)
- 2.1.7 Substance that reacts with water to form a weak base solution. (1)
- 2.1.8 Salt that is slightly acidic. (1)
- 2.2 Ammonia (NH₃) has a boiling point of -33 °C while water boils at 100 °C at sea level. Ammonia dissolves easily into water to form a homogenous solution.
- 2.2.1 Define solution. (2)
- 2.2.2 State the type of intermolecular force that exists between NH₃ molecules. (2)
- 2.2.3 Water is a liquid and NH₃ is a gas at room temperature. Why do their boiling points differ so significantly? (2)

- 2.3 Graphite is a molecule that consists of only carbon atoms. A diagram of graphite is shown below:



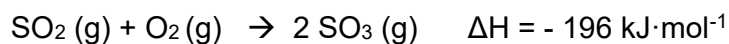
$$1 \text{ \AA} = 1 \times 10^{-10} \text{ m}$$

- 2.3.1 State whether the bonds between atoms are intermolecular or intramolecular. (1)
- 2.3.2 Are the bonds within layers stronger or weaker than the bonds between layers? Explain your reasoning. (3)

[18]

Question 3 - Rates

Consider a reaction that is used in the manufacture of sulphuric acid.



3.1 Define the following terms:

3.1.1 Reaction Rate (2)

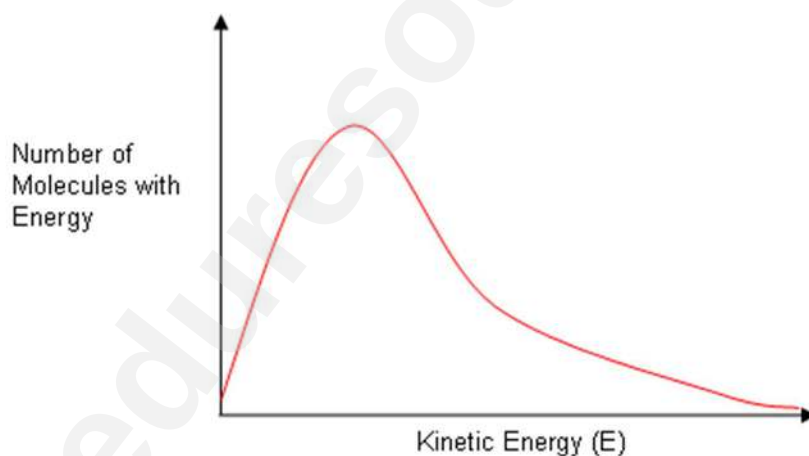
3.1.2 Activation energy (2)

3.2 A learner incorrectly states that “a catalyst lowers the activation energy which results in more collisions taking place per second”

3.2.1 How does the catalyst reduce the activation energy? (1)

3.2.2 Use collision theory to explain why the rate increases when a catalyst is added to the system. (3)

3.3 Another way of changing the rate of reaction is to decrease the temperature. Sketch on the answer sheet the new Boltzmann distribution for the sample of gas at a **LOWER** temperature. (3)



3.4 On the potential energy profile, provided on the answer sheet, add labels and where appropriate arrows to illustrate the following:

3.4.1 Activation energy

3.4.2 Enthalpy change (ΔH)

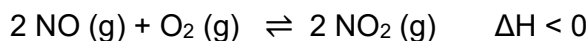
3.4.3 Activated complex

(5)

[16]

Question 4 – Chemical Equilibrium

- 4.1 NO gas is a polluting gas that is released by petrol and diesel engines. The gas undergoes the following reaction to form NO₂ and can establish an equilibrium in a closed system.



Colourless

Brown

- 4.1.1 Define closed system. (2)
- 4.1.2 Is this a redox reaction? Yes or No. (1)
- 4.1.3 Would the rate of the forward reaction increase or decrease when pressure is increased? Explain your answer using collision theory. (4)
- 4.1.4 Would you expect the brown colour to get darker or less dark if the pressure is increased? Explain. (2)
- 4.1.5 Write the K_c expression for this reaction. (2)
- 4.1.6 The volume of the system is 500 cm³. Initially 0,7 mol of NO and 0,9 mol of O₂ is placed in the container and the container sealed. At equilibrium 0,4 mol of NO₂ is present. Calculate the K_c value for this system at this temperature. (6)
- 4.2 Write only **INCREASE**, **DECREASE** or **NO EFFECT** for the following questions that refer to the equation above.
- 4.2.1 How will the addition of a catalyst affect the yield of NO₂? (1)
- 4.2.2 How will the addition of more NO affect the amount of NO₂ when equilibrium is re-established? (2)
- 4.2.3 How will a decrease in pressure affect the number of moles of O₂ when equilibrium is re-established? (2)
- 4.2.4 How will a decrease in temperature affect the K_c value when equilibrium has been re-established? (2)
- 4.2.5 What happens to the rate of the reverse reaction, initially when temperature is decreased? (1)

[25]

Question 5 – Acids and Bases

A solution of the strong base $X(OH)_2$ is prepared by dissolving $X(OH)_2$ into water and the concentration of $X(OH)_2$ is $0,2 \text{ mol} \cdot \text{dm}^{-3}$. **This solution of $X(OH)_2$ is used for each of the questions that follow.**

5.1 Define the terms:

5.1.1 base (2)

5.1.2 strong base (2)

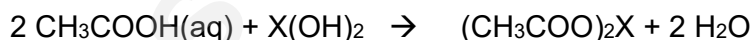
5.2 When $X(OH)_2$ is added to water it dissociates.

5.2.1 Write out the dissociation reaction for $X(OH)_2$ in water. Include phase symbols in your answer. (3)

5.2.2 What is the concentration of hydroxide ions in the solution? (1)

5.2.3 If 6,2 g of $X(OH)_2$ was dissolved in 500 cm^3 of water to make the solution, calculate the molar mass of $X(OH)_2$. (5)

5.3 The reaction between $X(OH)_2$ and the weak acid CH_3COOH produces an equivalence point that is weakly basic.

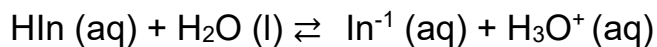


5.3.1 Define equivalence point. (2)

5.3.2 Name the acid being used. (1)

5.3.3 If $32,40 \text{ cm}^3$ of acid solution “neutralises” $25,00 \text{ cm}^3$ of the $X(OH)_2$ solution. Calculate the concentration of the acid solution. (6)

- 5.4 Bromocresol green is an indicator that is used in the reaction of a weak acid with a strong base. The bromocresol green molecule can be represented by the formula HIn that ionises in water according to the following reaction equation:



Yellow

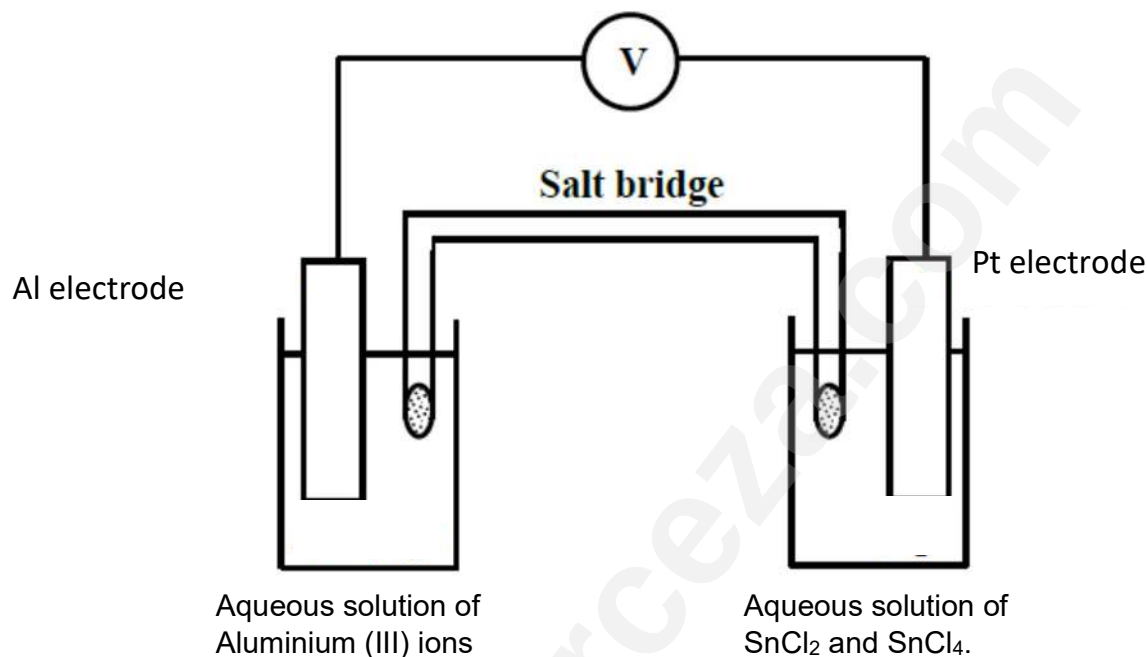
Blue

- 5.4.1 Classify bromocresol green as either an acid or a base. (1)
- 5.4.2 Would you consider bromocresol green as weak or strong? (1)
- 5.4.3 Explain the term “conjugate base”. (2)
- 5.4.4 Identify the conjugate acid/base pairs in this equilibrium. (2)
- 5.4.5 State Le Chatelier’s principle. (2)
- 5.4.6 When the bromocresol green is added to the strong base – would the solution be yellow or blue? (1)
- 5.4.7 Use Le Chatelier’s principle to explain your answer in 5.4.6 (4)

[35]

Question 6 – Redox Chemistry

A cell is set-up under standard conditions as illustrated below:



An aluminium electrode is immersed in a solution of aluminium (III) ions. An aqueous mixture of soluble SnCl_2 and SnCl_4 is placed in the other half cell with a platinum electrode.

6.1 A platinum electrode is used in the tin half-cell.

6.1.1 Could a zinc electrode be used instead of platinum? Explain your reasoning. (2)

6.1.2 Calculate the reading on the voltmeter (3)

A light bulb is now placed across the anode and cathode of the cell.

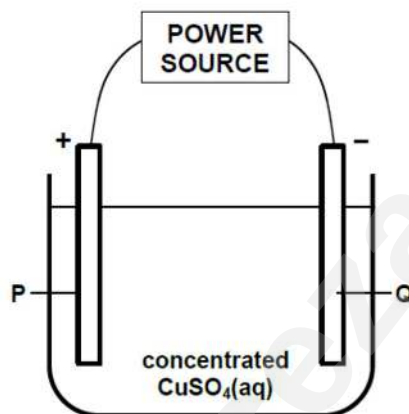
- 6.2.1 Define the term “anode”. (2)
- 6.2.2 Write down the half-reaction that is taking place at the anode. (2)
- 6.2.3 Write down the half-reaction that is taking place at the cathode. (2)
- 6.2.4 Determine the overall net ionic reaction for this cell. (2)
- 6.2.5 Write down the cell notation for this cell. Include standard conditions and phase symbols. (5)
- 6.3 When operating, more SnCl_4 is dissolved into the tin half-cell.
 - 6.3.1 Would you expect there to be a change in the voltmeter reading?
Explain your reasoning. (2)
 - 6.3.2 While the cell operates, does the platinum electrode gain mass, lose mass or remain the same? Explain your reasoning. (2)
 - 6.3.3 While operating, the cell may heat up. Would you expect the voltage to change as a result? Explain. (3)
- 6.4 The salt bridge plays a crucial role in the cell.
 - 6.4.1 State the functions of a salt bridge. (2)
 - 6.4.2 Suggest a suitable salt that can be used in the salt bridge. (1)
 - 6.4.3 Explain how the salt bridge enables charges to move in the cell. (3)

[31]

Question 7 – Copper Purification and Plating

Copper is a metal with high conductivity and is widely used for wiring and in electrical transmission. Impurity in the copper reduces the conductivity of the copper and they are removed through a purification process.

Impure blister copper is electro-refined using the following process. Electrode P is the blister copper. Aqueous copper sulphate are used as the electrolyte.



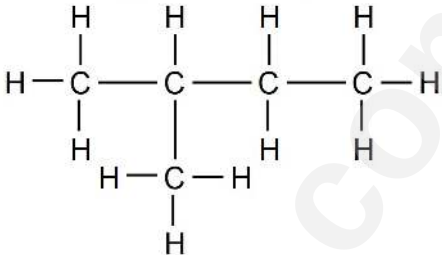
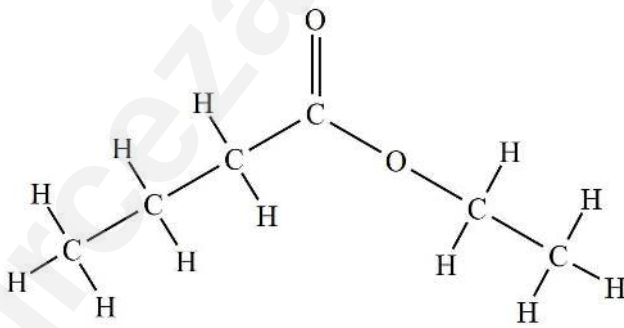
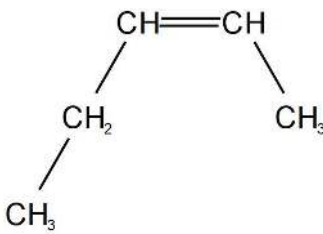
- 7.1 Is the anode P or Q? (1)
- 7.2 Define electrolyte. (2)
- 7.3 The blister copper contains silver and zinc metals as impurities.
 - 7.3.1 Does silver react and go into solution? Explain. (2)
 - 7.3.2 Zinc goes into solution but does not form at the pure copper electrode. Explain why only copper forms at the pure copper electrode and not zinc metal. (3)
 - 7.3.3 If a current of 500 A runs for 10 hours, calculate the mass of pure copper that is deposited at Q. (6)

[14]

Question 8 – Organic Chemistry

Organic molecules undergo a range of chemical reactions based on their structure.

A number of molecules is listed in the table below.

A	
B	
C	<chem>CH2CHCH2CH3</chem>
D	butan-2-ol
E	2-bromohexane
F	

8.1 Write down only the letter/s of the molecule/s that

8.1.1 exhibit hydrogen bonding

8.1.2 is an ester

8.1.3 can undergo elimination reactions

8.1.4 is unsaturated

(6)

NOTE : Letters may be used more than once or not at all.

- 8.2.1 Name molecule A (2)
 - 8.2.2 Name molecule B (3)
 - 8.2.3 Name molecule F (3)
 - 8.3 Molecule F will react with steam in the presence of H_2SO_4 .
 - 8.3.1 Draw the full structural formula for the product of this reaction. (2)
 - 8.3.2 State the type of reaction that has taken place. (1)
 - 8.4 Molecule E can undergo a reaction with the aqueous NaOH, while being gently warmed.
 - 8.4.1 Draw the structural formula of the product of the reaction. (3)
 - 8.4.2 State the type of reaction that takes place. (2)
- [22]**

Question 9 – Hexane and Hexene

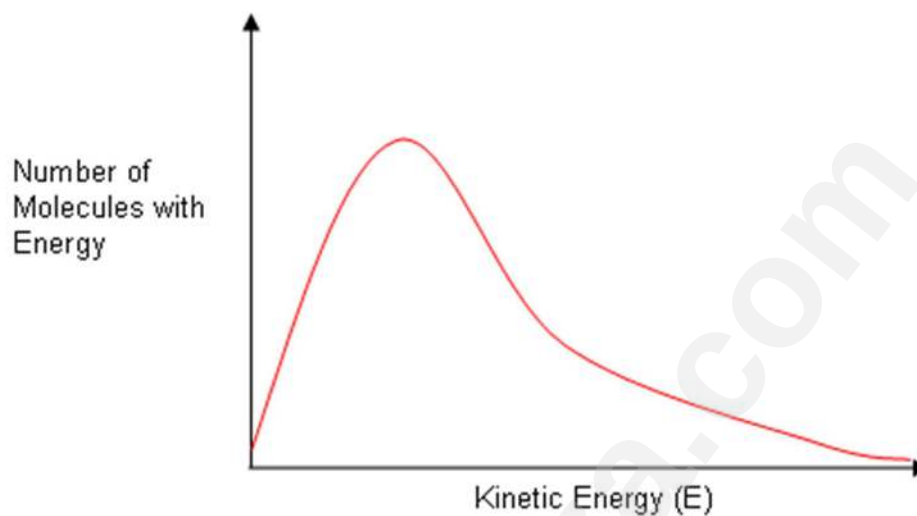
Consider the molecules hexane and hexene.

- 9.1 Write down the molecular formula for the hexane molecule. (2)
- 9.2 Write down the general formulae for the homologous series to which hexene molecules belong. (2)
- 9.3 James observes that hexane and hexene are functional isomers of each other.
- 9.3.1 Define the term isomer. (2)
- 9.3.2 Do you agree with James? Explain your reasoning. (2)
- 9.4 Write down the combustion reaction for hexane with excess oxygen. (4)
- 9.5 Hexane can be cracked to form other molecules. If one product of the cracking of a hexane molecule is ethane, suggest the NAME of the other product that forms. (2)
- 9.6 You have been given 2 colourless liquids. You are told that one is an alkane and that the other is an alkene.
- 9.6.1 Explain how you would perform a chemical test to determine which substance is the alkene and which is the alkane. (3)
- 9.6.2 What does the test tell us about the rate of a substitution reaction versus the rate of an addition reaction. (2)

[19]

Answer Sheet – NAME _____

3.3



3.4

Potential
Energy

