Anglo-Chinese School
(Barker Road)
A Methodist Institution
Founded in 1886

CHEMISTRY
DEPARTMENT OF SCIENCE

Name: ..... ( ) Class: SEC 4 .....

ENERGY CHANGES (EXTENSIONS) – ASSIGNMENT

Multiple-Choice Questions [20 Marks]

TOTAL SCORE / 30

Write in your selected answer for the multiple-choice questions in the boxes provided.

1	2	3	4	5	6	7	8	9	10

11	12	13	14	15	16	17	18	19	20

1. What is meant by an 'endothermic' reaction?

   A A catalyst is needed for the reaction to take place.
   B Light energy is absorbed during the reaction.
   C The reactants have less energy than the products of the reaction.
   D They are chemical reactions which require heat to start.

2. A pupil added 0.06 mol of sodium nitrate to 100 cm^3 of water at 20.0 °C. The enthalpy change of solution of sodium nitrate is +20.5 kJ/mol. After dissolving the solute, the temperature of the solution will be about

   A 18.0 °C **B** 20.0 °C **C** 23.0 °C **D** 26.0 °C

3. Early photographers used the oxidation of magnesium powder to produce flashes of light in the presence of oxygen from the air. Magnesium reacts according to the equation:

   $$\mathbf{2\ Mg\ (s) + O_2\ (g) \longrightarrow 2\ MgO\ (s) \quad \Delta H = -2400\ kJ/mol}$$

   When 0.24 g of magnesium reacts with excess oxygen, the energy released would be

   A 3.00 kJ **B** 6.00 kJ **C** 12.0 kJ **D** 24.0 kJ

4. The combustion of octane, C_8H_{18}, can be expressed in the equation below.

   $$\mathbf{2\ C_8H_{18}\ (l) + 25\ O_2\ (g) \longrightarrow 16\ CO_2\ (g) + 18\ H_2O\ (g)}$$

   Given that combusting 57 grams of octane results in **x** kJ of energy being evolved, what is the enthalpy change for the above reaction?

   A + **x** kJ **B** + 2**x** kJ **C** − 0.5**x** kJ **D** − 4**x** kJ

5. The hydration of quicklime to become slaked lime is an exothermic reaction, and can be expressed in the following equation:

$$\mathbf{CaO\ (s) + H_2O\ (l) \longrightarrow Ca(OH)_2\ (s) \quad \Delta H = -65.2\ kJ/mol}$$

An unknown mass of quicklime was reacted as above. Given that the mass of the quicklime increased by 37.3 grams in the reaction, calculate the energy evolved.

A 32.9 kJ **B** 43.4 kJ **C** 65.2 kJ **D** 135 kJ

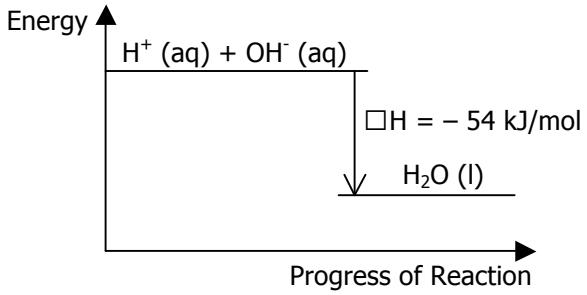
6. Hydrogen reacts with chlorine.

$$\mathbf{H_2\ (g) + Cl_2\ (g) \longrightarrow 2\ HCl\ (g) \quad \Delta H = -184\ kJ/mol}$$

Why does the enthalpy change for this reaction have a negative sign?

A Hydrogen and chlorine are covalent, but hydrogen chloride is ionic.
B More bonds are formed than are broken.
C The speed of the reaction increases as temperature increases.
D The total energy of bond breaking is less than that of bond forming.

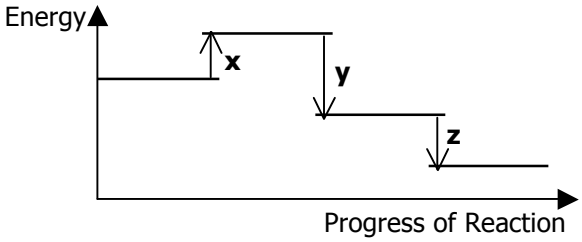
7. The energy level diagram for the reaction between aqueous sodium hydroxide and dilute hydrochloric acid is shown.



What can be deduced from the diagram?

A The OH^- ions have more energy than the H^+ ions.
B The products contain less energy than the reactants.
C The reaction has a high activation energy.
D The reaction occurs readily at room temperature.

8. A series of chemical reactions are represented in the energy level diagram below.



Given that **x**, **y** and **z** are positive numbers, the enthalpy change of the overall reaction is

A (**x** + **y**) − **z** **B** **x** − (**y** + **z**) **C** **x** + **y** + **z** **D** **y** + **z**

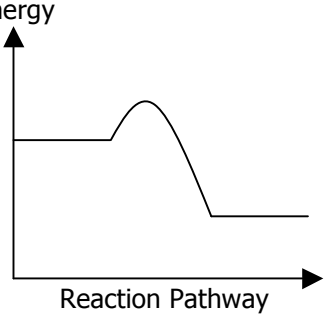
9. The reaction between chlorine and methane can be expressed as four steps:

Step **I**: Cl_2 (g) ⟶ 2 Cl (g) ☐H = + 243 kJ/mol
Step **II**: Cl (g) + CH_4 (g) ⟶ CH_4Cl (g) ☐H = − 330 kJ/mol
Step **III**: CH_4Cl (g) ⟶ CH_3Cl (g) + H (g) ☐H = + 413 kJ/mol
Step **IV**: H (g) + Cl (g) ⟶ HCl (g) ☐H = − 432 kJ/mol

Using the information provided above, what is the enthalpy change of the overall reaction, Cl_2 (g) + CH_4 (g) ⟶ CH_3Cl (g) + HCl (g)?

A + 137 kJ/mol **B** − 106 kJ/mol **C** − 228 kJ/mol **D** − 455 kJ/mol

10. Which of the following energy profile diagrams shows the fastest exothermic reaction?

A


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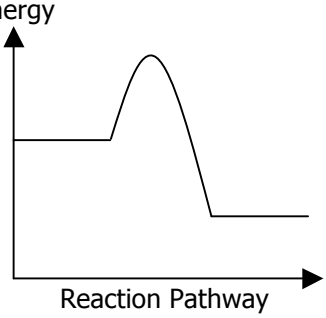

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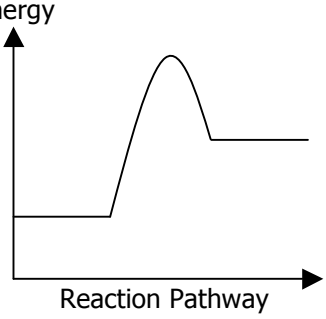
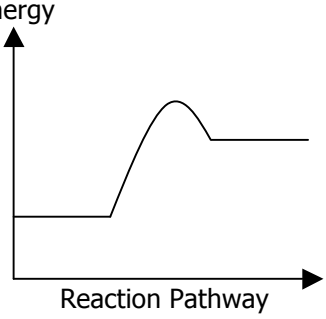
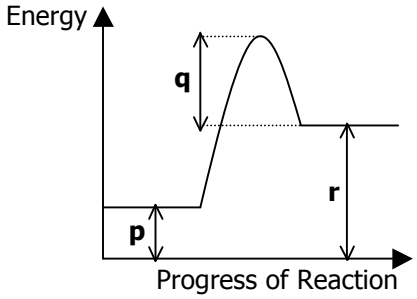


D


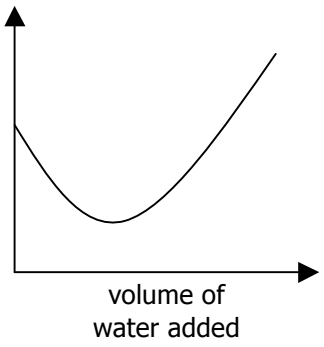
11. In the energy profile diagram below, which represents the enthalpy change and the activation energy respectively?



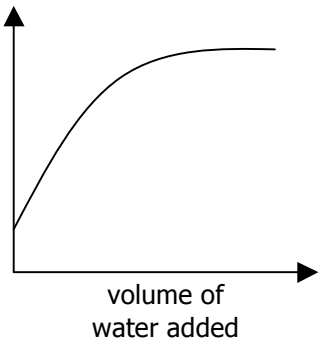
	enthalpy change	*activation energy*
A	**p**	**q**
B	**q**	**q** + (**r** − **p**)
C	**r**	**q**
D	**r** − **p**	**q** + (**r** − **p**)

12. When glucose is dissolved into water, attractive forces are initially formed between the glucose molecules and the water molecules. As more water is added, these attractive forces are gradually broken. Which of the following graphs shows how the temperature of the resulting solution varies as water is added?

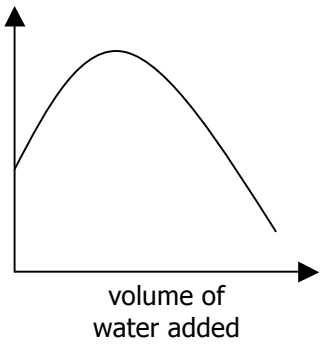
A



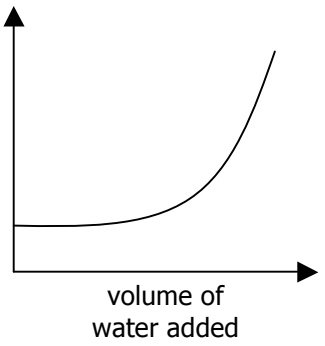
C



B



D



13. The formation of ethanol from ethane and steam is shown in the following equation:

$$C_2H_4\,(g) + H_2O\,(g) \rightleftharpoons C_2H_5OH\,(g), \quad \Delta H = -50\ kJ/mol$$

Under which conditions would the above reaction provide the greatest yield?

	temperature	*pressure*
A	high temperature	high pressure
B	high temperature	low pressure
C	low temperature	high pressure
D	low temperature	low pressure

14. The production of synthetic diamonds is very difficult although the conversion of graphite into diamond is only very slightly endothermic.

$$C\,(graphite) \longrightarrow C\,(diamond) \quad \Delta H = +2.1\ kJ/mol$$

Which of the following help to explain this observation?

(i) The activation energy of the reaction is large.
(ii) An equilibrium exists between diamond and graphite.
(iii) Only exothermic reactions can be made to occur readily.

A (i) only **B** (ii) only **C** (i) and (iii) only **D** (ii) and (iii) only

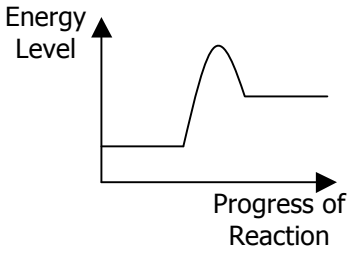
15. Which of the following statements about reversible reactions is **true**?

A A higher temperature increases the speed of all reversible reactions.
B Endothermic reversible reactions obtain a greater yield under low temperatures.
C Exothermic reversible reactions occur the fastest under low temperatures.
D Reversible reactions do not require activation energy to occur.

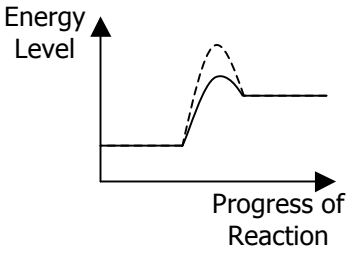
16. Which of the following statements pertaining to catalysts is true?

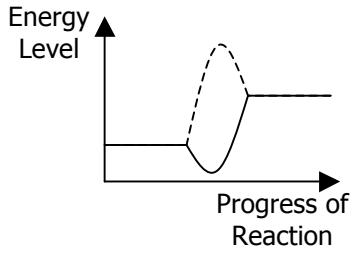
A A catalyst decreases the enthalpy change of an endothermic reaction.
B A catalyst increase the yield of reversible reaction.
C A catalyst remains physically unchanged throughout the chemical reaction.
D A catalyst increases the speed of both the forward and backward reactions.

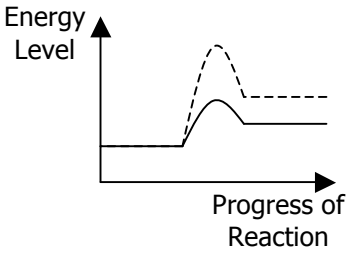
17. The energy profile diagram of a chemical reaction is shown below.

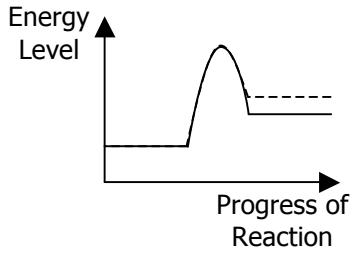


Which of the following shows how the energy profile diagram of a reaction would change when a catalyst is added to the reaction vessel?

A


C


B


D


18. A metal **M** was placed in aqueous copper(II) nitrate. A reddish-brown solid was obtained, and the temperature of the reaction mixture rose.

Which of the following conclusions cannot be deduced from this information?

A **M** has the same valency as copper.
B **M** has been oxidised.
C **M** is more reactive than copper.
D The reaction is exothermic.

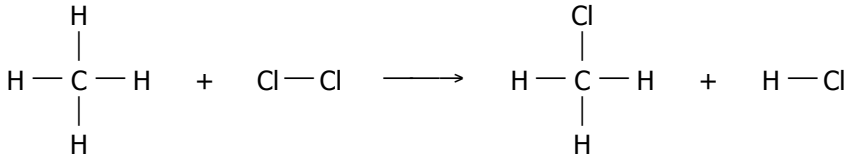
19. Consider the following bond energies.

Type of Bond	kJ mol^{-1}
C – C	346
C – H	410
Si – Si	176
Si – H	318

Which of the following statements could be considered to be consistent with these values?

A 346 kJ is the amount of energy evolved when 1 mole of graphite sublimes.
B Methane, CH_4, is chemically more stable than silane, SiH_4.
C The C – C bond is less stable than the Si – Si bond.
D The Si – Si bond is the least readily broken among all.

20. Consider the chemical reaction below, which has an enthalpy change of –117 kJ mol^{-1}.



Some bond energies, relevant to this equation, are also provided below.

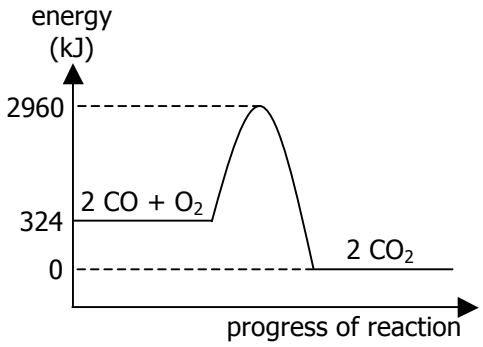
Type of Bond	kJ mol^{-1}
C – H	410
C – Cl	340
H – Cl	431

What is the strength of the Cl – Cl bond?

A 244 kJ mol^{-1} **B** 361 kJ mol^{-1} **C** 478 kJ mol^{-1} **D** 618 kJ mol^{-1}

Structured Questions [10 Marks]

21. The reaction between carbon monoxide and oxygen, 2 CO + O_2 ⟶ 2 CO_2, can be expressed in the energy profile diagram below.



(a) In the diagram above, label the activation energy, ΔE_a. [1]

(b) Given that the strength of the O=O bond is 496 kJ/mol, and the strength of the C=O bond is 740 kJ/mol, calculate the strength of the bond in carbon monoxide. [2]

22. Hydrogen chloride can be manufactured by reacting hydrogen and chlorine together. The enthalpy change for the reaction is –182 kJ/mol.

$$H - H + Cl - Cl \longrightarrow 2\ H - Cl$$

(a) Explain, in terms of the bonds broken and bonds formed, why the reaction between hydrogen and chlorine is exothermic. [1]

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(b) Draw an energy level diagram for the above reaction. [2]

23. Some space rockets use hydrazine, N_2H_4, as a fuel. It reacts with hydrogen peroxide, H_2O_2 to form nitrogen and water.

(a) Construct a chemical equation for the above reaction. [1]

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(b) A table of bond energies is provided below. Using the table, calculate the enthalpy change for the reaction in (a). [3]

Bond	**Energy** *kJ/mol*	**Bond**	**Energy** *kJ/mol*	**Bond**	**Energy** *kJ/mol*
N≡N	994	N–N	160	O–O	150
N=N	410	N–H	390	O–H	460

END