

Section A

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

- 1 Ether has the formula, CH_3OCH_3 .

In a sample of ether, 8.7 % contains the ^{18}O isotope, with the rest contains the ^{16}O isotope.

What is the relative molecular mass of ether in this sample?

A 46.2

B 46.8

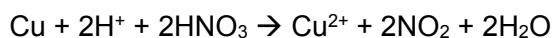
C 47.2

D 47.8

Ar of O = $8.7 \times 18 + 91.3 \times 16 / 100 = 16.174$

Relative Molecular Mass = $16.174 + 12 + 3 + 12 + 3 = 46.174 = 46.2$

- 2 Copper reacts with dilute nitric acid to produce nitrogen dioxide gas. The balanced ionic equation is given.



Which of the following is correct?

	Oxidation state of N in		Role of copper
	HNO_3	NO_2	
A	+5	-3	Reducing agent
B	+5	+4	Reducing agent
C	-5	-3	Oxidising agent
D	-5	+4	Oxidising agent

Cu is being oxidised. It is a reducing agent.

$\text{HNO}_3 = (+1) + ? + 3(-2) = 0$

$? = +5$

$\text{NO}_2 = ? + 2(-2) = 0$

$? = +4$

- 3 10 cm³ of propane was completely burnt in x cm³ of excess oxygen. After cooling to room temperature, the volume of the residual gas was 60 cm³. The residual gas was passed through aqueous sodium hydroxide and the volume reduced to y cm³.

Which of the following is correct?

	x	y
A	50	30
B	60	20
C	70	20
D	80	30



10cm³ requires 50cm³ of oxygen for complete combustion and 30cm³ of CO₂ will be produced. Hence $x = 50 + (60-30) = 80$ cm³. $y = \text{volume of excess oxygen} = 60-30$ cm³

- 4 An organic compound with the formula $\text{C}_x\text{H}_y\text{O}_2$ has undergone incomplete combustion, producing carbon dioxide and carbon monoxide in the ratio of 99 : 1.

The equation may be represented as follows:



a , b and c can be expressed in terms of x and y .

Which of the following is correct?

	a	b	c
A	$99x + 0.5x + 0.25y - 1$	x	$99x$
B	$99x + 0.5x + 0.25y$	x	$99x$
C	$0.99x + 0.005x + 0.25y - 1$	$0.01x$	$0.99x$
D	$0.99x + 0.005x + 0.25y$	$0.01x$	$0.99x$

$$C = 0.01x + 0.99x = x$$

Check by balancing O atoms on both sides,

$$2 + 2(0.99x + 0.005x + 0.25y - 1) = 0.01x + 0.99x(2) + 0.5y$$

$$1.98x + 0.01x + 0.50y = 1.99x + 0.5y$$

- 5 *Use of the Data Booklet is relevant to this question.*

The components of a 100 g sample of fertilizer is as shown in the table below:

Element	Mass / g
N	15
P	30
K	15
Other Elements	40

The recommended usage of fertilizer is 14 g of fertilizer per 5 dm³ of water.

What is the concentration of nitrogen atoms in this recommended solution?

- A** 0.03 mol dm⁻³
B 0.15 mol dm⁻³
C 0.42 mol dm⁻³
D 0.75 mol dm⁻³

15/100 x 14grams = 2.1 grams
 No of moles of N = 2.1/14 = 0.15mol
 Concentration = 0.15/5 = 0.03 mol dm⁻³

- 6 The elements **X** and **Y** are in Group 16 and 17 respectively in the same period.

Which of the following statements regarding **X** and **Y** is most likely to be true?

- A** **Y** has more unpaired electrons than **X**.
B **Y** atom is bigger than **X** atom.
C **X** is more electronegative than **Y**.
D The first ionisation energy of **X** will likely be less endothermic than that of **Y**.

X: ns²np⁴
 Y: ns²np⁵ => less unpaired electrons than X

Y has more protons than X. Thus Y would be smaller than X. The electrons are more strongly attracted to the nucleus in Y than X. Thus Y would be more electronegative than X. More energy is needed to remove 1st electron from its nucleus.

7 The table gives the successive ionisation energies for an element X.

	1st	2nd	3 rd	4th	5th	6th
ionisation energy/ kJ mol ⁻¹	950	1800	2700	4800	6000	12300

What could be the formula of the fluoride of X?

A XF

B XF₂

C XF₃

D XF₄

The greatest jump in energy is between 3rd and 4th IE. Thus 3 valence electrons are in X which means that the highest oxidation number of X is +3.

8	<p>'Dot-and-cross' diagrams for carbon monoxide are shown below.</p> <p>Which circle pair of electrons represent a co-ordinate bond?</p>	
	A	
	B	
	C	
	D	

Coordinate bond is a covalent bond in which both electrons come from the same atom.

9 Which of the following molecules is linear and non-polar?

A CS_2

B SCN

C SO_2

D SiO_2



10 Consider the following four compounds.

1 $\text{CH}_3\text{CH}_2\text{CH}_2\text{F}$

2 $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$

3 $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$

4 $(\text{CH}_3)_3\text{CH}$

What is the order of increasing boiling points of the compounds (from lowest to highest)?

A $2 \rightarrow 1 \rightarrow 3 \rightarrow 4$

B $4 \rightarrow 3 \rightarrow 2 \rightarrow 1$

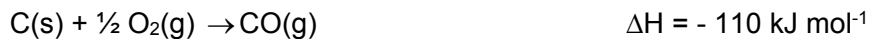
C $3 \rightarrow 1 \rightarrow 2 \rightarrow 4$

D $4 \rightarrow 3 \rightarrow 1 \rightarrow 2$

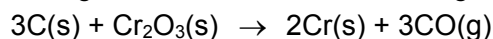
Compound 2 has hydrogen bonds between its molecules. Compound 1 is polar and has dipole-dipole interactions between its molecules.

Compound 3 and 4 are both structural isomers. Compound 3 is linear whereas compound 4 is branched. Thus compound 3 has more London dispersion interactions due to bigger surface area than compound 4.

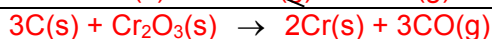
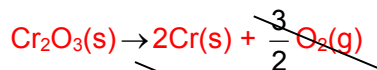
- 11 The enthalpy changes for two reactions are given by the equations:



What is the enthalpy change, in kJ mol^{-1} , for the following reaction?

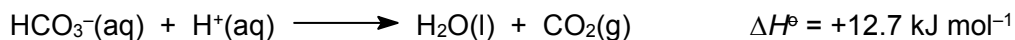


- A -800
B +800
 C -1460
 D +1460



Enthalpy change of reaction = $-110(3) + 1130 = +800 \text{ kJ mol}^{-1}$

- 12 Hydrogencarbonate may react with acid according to the equation below.



Using the following enthalpy changes of formation provided, what is the standard enthalpy change of formation of $\text{H}^+\text{(aq)}$?

species	$\Delta H_f^\ominus / \text{kJ mol}^{-1}$
$\text{H}_2\text{O(l)}$	-285.8
$\text{CO}_2\text{(g)}$	-393.5
$\text{HCO}_3^-\text{(aq)}$	-692.0

- A $-25.4 \text{ kJ mol}^{-1}$
B 0.0 kJ mol^{-1}
 C $+25.4 \text{ kJ mol}^{-1}$
 D $+1384 \text{ kJ mol}^{-1}$

$$\begin{aligned} \Delta H &= \Delta H_f(\text{products}) - \Delta H_f(\text{reactants}) \\ +12.7 &= -285.8 - 393.5 - (-692.0 + \Delta H_{\text{H}^+}) \\ \Delta H_{\text{H}^+} &= 0 \end{aligned}$$

- 13 In an experiment, 70 cm³ of water at 25 °C was brought to boil by burning butane in excess oxygen. Calculate the volume of butane required if this process is only 85 % efficient.

[ΔH_c (butane) = -2877 kJ mol⁻¹; $c = 4.2 \text{ J g}^{-1} \text{ K}^{-1}$; Molar volume of gas under the given conditions = 24 dm³]

- A 0.0721 dm³ B 0.156 dm³ C 0.184 dm³ **D 0.216 dm³**

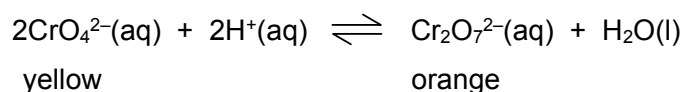
Heat absorbed = $Q = mc\Delta T = 70 \times 4.18 \times 75 = 21\,945 \text{ J}$

Heat released = $100/85 \times 21\,945 = 25\,817 \text{ J}$

No of moles of butane = $25\,817 \times 10^{-3} / 2877 = 0.008973 \text{ mol}$

Volume = $0.008973 \times 24 = 0.216 \text{ dm}^3$

- 14 Which statement concerning the equilibrium reaction given below is correct?



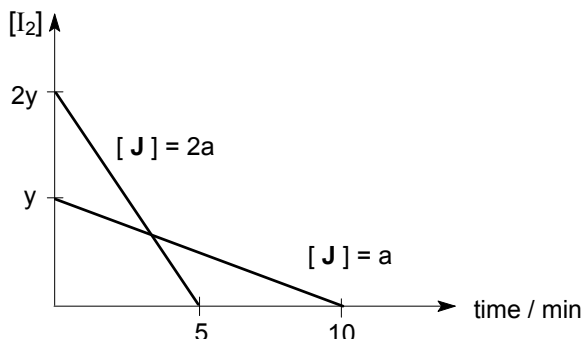
- A It is a redox reaction.
- B The equilibrium constant, K_c , has the units of mol⁻² dm⁶.
- C The colour of the solution change from orange to yellow when pH increases.**
- D The addition of a catalyst will result in an increase in the concentration of $\text{Cr}_2\text{O}_7^{2-}(\text{aq})$.

There is no change in oxidation state of Cr (+6 in both species).

$K_c = [\text{Cr}_2\text{O}_7^{2-}]/[\text{CrO}_4^{2-}]^2[\text{H}^+]^2$ hence, units is mol⁻³dm⁹

pH increases implies that there is a decrease in H^+ . By LCP, system shifts to the left as more H^+ ions are produced.

- 15 The kinetics of the reaction between iodine and compound **J** is investigated.



What conclusions can be drawn from the graphs?

- A** The reaction is second order with respect to compound **J** because rate of reaction increases by four times when its concentration is increased by two times.
- B** Both iodine and compound **J** react in equal mole ratio.
- C** The reaction is first order with respect to iodine because half-life is constant.
- D** The overall order of the reaction is 1.

Gradient represents the rate of reaction. As $[J]$ doubles, gradient of the graph quadruples. This implies that it is a 2nd order reaction.

- 16 **X**, **Y** and **Z** are elements in Period 3 of the Periodic Table.

A mixture containing the oxides of **X**, **Y** and **Z** was dissolved in excess dilute sulfuric acid and filtered. The oxide of **Z** was collected as a residue. When excess dilute sodium hydroxide was added to the filtrate, only a white precipitate of the hydroxide of **Y** was formed.

What are the possible identities of **X**, **Y** and **Z**?

	X	Y	Z
A	Mg	Al	P
B	Al	Mg	P
C	Mg	Al	Si
D	Al	Mg	Si

Z has to be an insoluble oxide which is silicon oxide. **X** oxide is soluble in acid and base. This **X** oxide is aluminium oxide which is amphoteric in nature.

- 17 The oxide and chloride of an element X are separately mixed with water. The two resulting solutions have the same effect on litmus solution.

What is element X?

- A Sodium
- B Magnesium
- C Aluminum
- D Phosphorus

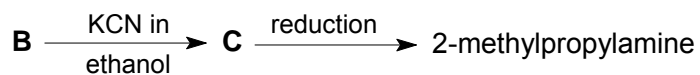
Phosphorus oxide dissolves in water to give rise to acidic solution of phosphoric acid. Phosphorus chlorides also give rise to hydrochloric acid and phosphoric acid when it is hydrolysed in water.

- 18 Which property of benzene is reflected as a consequence of the delocalised electrons present in its molecule?

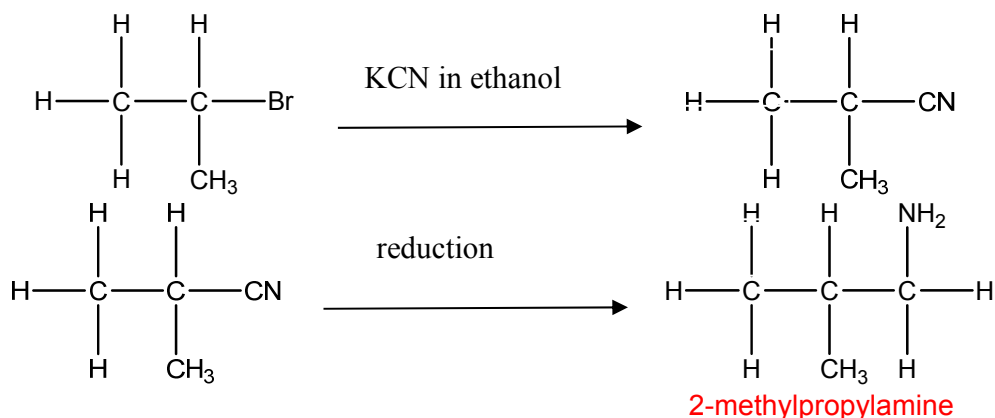
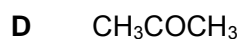
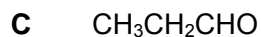
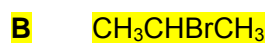
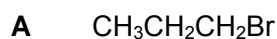
- A Benzene is cyclic.
- B Benzene is a planar molecule.
- C Benzene is a good conductor of electricity.
- D Substitution on benzene takes place more easily than addition reactions.

Substitution would be easier as compared to addition as resonance structure of benzene would keep the stable system intact.

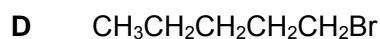
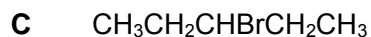
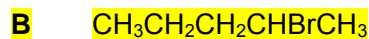
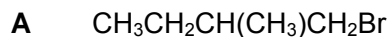
- 19 2-methylpropylamine, $(\text{CH}_3)_2\text{CHCH}_2\text{NH}_2$ can be produced by the following reaction scheme starting with compound **B**.

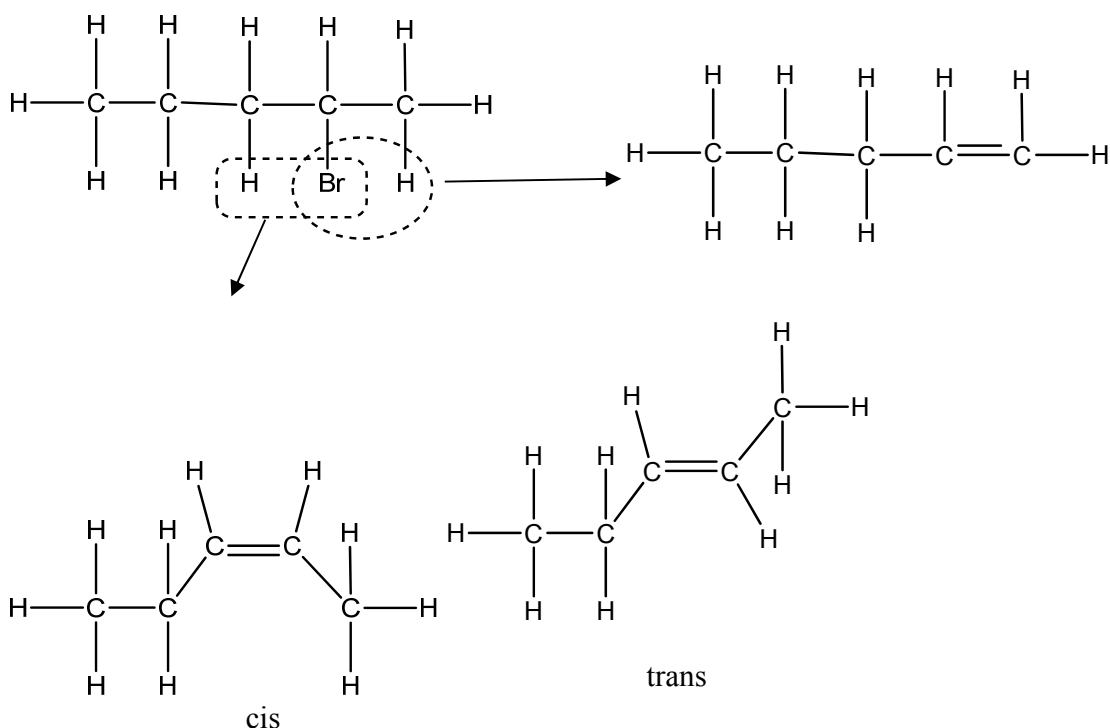


Which one of the following compounds is **B** likely to be?

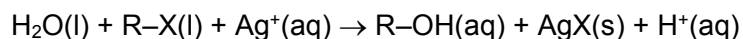


- 20 Which of the following isomers of $\text{C}_5\text{H}_{11}\text{Br}$ gives the greatest number of different alkenes on treatment with hot ethanolic sodium hydroxide?





- 21 Four drops of 1-chlorobutane, 1-bromobutane and 1-iodobutane were separately added to three test-tubes containing 1.0 cm³ of aqueous silver nitrate at 60 °C. The following reaction occurred.



[R: C₄H₉–; X: halogen]

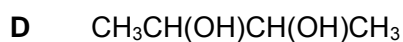
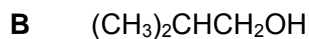
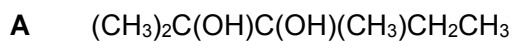
Which of the following best explains why the rate of formation of cloudiness (precipitate) in the tubes was in the order $\text{RCI} < \text{RBr} < \text{RI}$?

- A The R–X bond polarity decreases from RCI to RI.
- B The bond energy of R–X decreases from RCI to RI.**
- C The solubility of AgX(s) decreases from AgCI to AgI.
- D The ionisation energy of the halogen decreases from CI to I.

I is bigger than Cl. Thus the overlapping of orbitals between C-I is less effective as compared C-Cl and the bond strength is weaker.

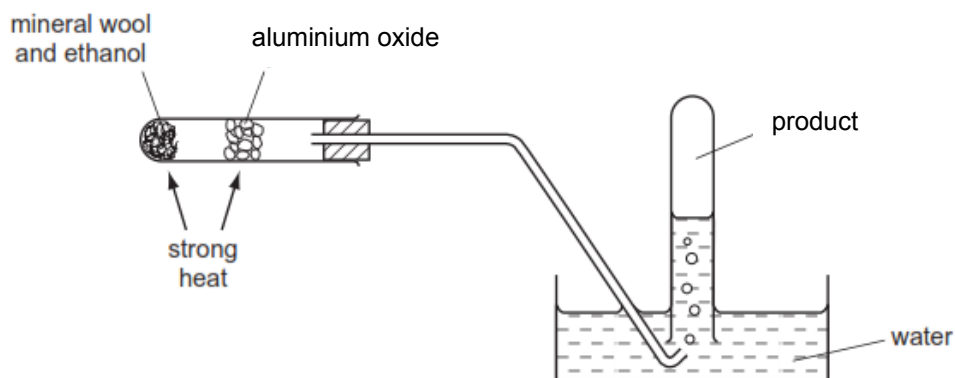
22 Which one of the following compounds:

- (i) is unaffected by hot alkaline potassium manganate(VII);
- (ii) produces 0.5 mol of hydrogen when 1 mol of compound is treated with excess sodium?

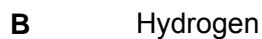


A and C are unaffected by oxidation due to tertiary alcohols. C can produce 0.5 mol of hydrogen gas as 1 mol of H^+ is given out from 1 mol of compound.

23 The diagram shows an experimental set-up.



Which compound can be produced by using the above apparatus?



Ethene gas and water are produced as the ethanol is dehydrated.

- 24 An alcohol of molecular formula $C_4H_{10}O_2$ contains two -OH groups and has an unbranched carbon chain.

On reaction with an excess of acidified potassium manganate(VII), this alcohol is converted into a compound of molecular formula $C_4H_6O_4$.

To which two carbons in the chain of the alcohol are the two -OH groups attached?

- A 1st and 2nd
- B 1st and 3rd
- C 1st and 4th**
- D 2nd and 3rd



An Increase by 2 O atoms implies that two primary alcohol functional groups have been converted to 2 carboxylic acid functional groups with 4 oxygen atoms. The two primary alcohol functional groups must be situated at the 1st and 4th carbons.

- 25 Which of the following reagents and conditions can distinguish between ethyl methanoate and ethyl ethanoate?

- A Heat with NaOH(aq)
- B Heat with H_2SO_4 (aq)
- C Heat with NaOH(aq) followed by Na_2CO_3 (aq)
- D Heat with H_2SO_4 (aq) followed by $KMnO_4$ (aq)**

Hydrolysis occurs. Both esters give ethanol, but 1 compound gives ethanoic acid and the other gives methanoic acid which will in turn be oxidised to carbon dioxide and water. Both will decolourise $KMnO_4$ but only ethyl methanoate will give carbon dioxide which will turn limewater chalky.

Section B

For each of the questions in this section, one or more of the three numbered statements 1 to 3 may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is used as a correct response.

- 26 The pH range and colour changes for two indicators are given below.

Indicator	pH range
X	violet 3.0 – 5.0 red
Y	yellow 5.6 – 7.6 blue

Which of the following solutions will give a red solution when indicator **X** is used and a yellow solution when indicator **Y** is used?

- 1 0.1 mol dm⁻³ HX ($K_a = 2.5 \times 10^{-10}$ mol dm⁻³)
- 2 0.1 mol dm⁻³ CH₃COOH ($K_a = 1.8 \times 10^{-5}$ mol dm⁻³)
- 3 0.1 mol dm⁻³ HCl

Option 1: pH = 5.3

indicator X colour would be red and indicator Y colour would be yellow

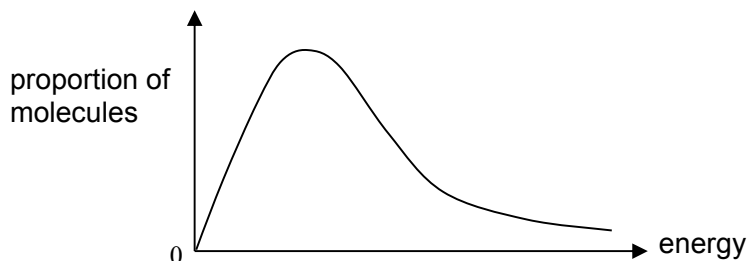
Option 2: pH = 2.87

indicator X colour would be violet and indicator Y colour would be yellow

Option 3: pH = 1

indicator X colour would be violet and indicator Y colour would be yellow

- 27 The graph below shows the Boltzmann distribution of molecular energies at a given temperature.

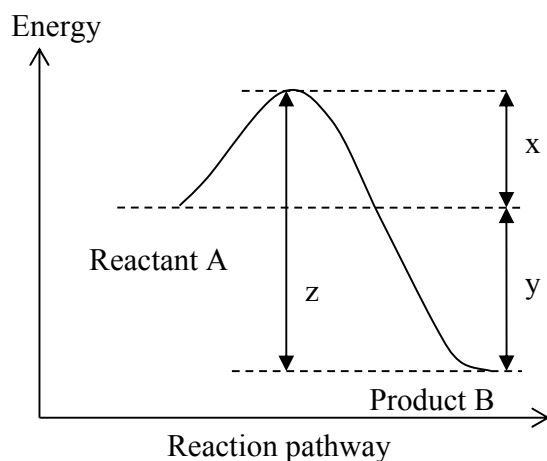


As temperature increases, which statements are correct?

- 1 The proportion of molecules with any given energy increases.
- 2 The maximum of the curve is displaced to the right.
- 3 The proportion of molecules with energies above any given value increases.

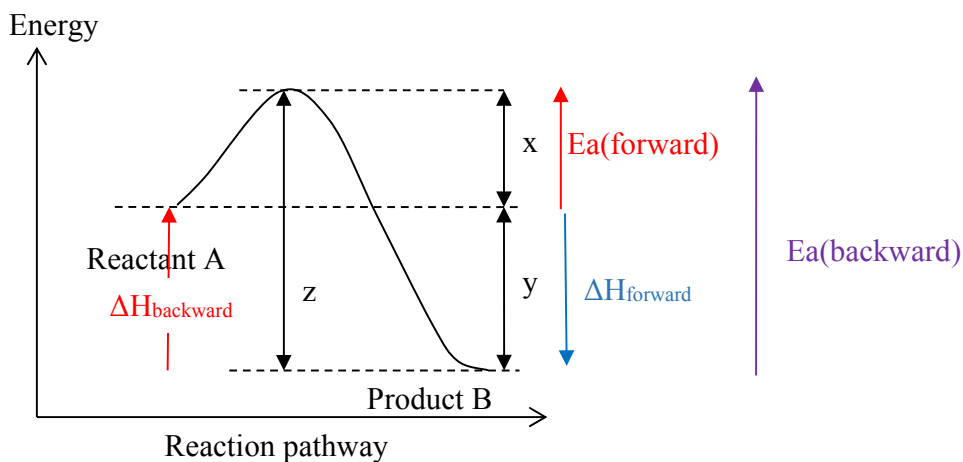
It is not true that the proportion of molecules with lower energy would increase. Maximum of curve displaces to the right as more particles gained higher in energy. The proportion of molecules with higher kinetic energy increases as T increases and hence would have energies greater than in their original state.

- 28 The energy profile for a reversible reaction is shown below.



Which of the following statement is/are **correct**?

- 1 The reaction from **B** to **A** is endothermic.
- 2 The activation energy of the reaction **A** to **B** is x .
- 3 The activation energy of the reaction **B** to **A** is $z - y$.



29 Which of the following show an increase in radius?

- 1 $Al < Mg < Na$
- 2 $Cl^- < S^{2-} < P^{3-}$
- 3 $Na^+ < Ca^{2+} < K^+$

Option 1: As proton number decreases, the electrostatic forces of attraction between nucleus and electrons decreases. Hence the atomic radius increases.

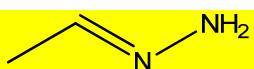
Option 2: As proton number decreases, the electrostatic forces of attraction between nucleus and electrons decreases. Thus the ionic radius increases.

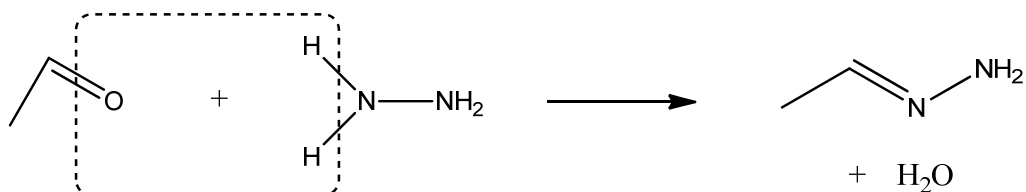
Option 3: Sodium ion has one less principal quantum shell than Ca ion and K ion. Thus it would be smaller than the other 2 elements. Ca ion has smaller ionic radius than K ion as it has one more proton than K ion.

30 The use of *Data Booklet* is relevant to this question.

Carbonyl compounds react with hydrazine, N_2H_4 , in the same manner as 2,4-dinitrophenylhydrazine.

Which of the following are correct?

- 1 The product is  when ethanal reacts with hydrazine.
- 2 The enthalpy change of the reaction is negative.
- 3 It is a condensation reaction.



ethanal	hydrazine	Product
		 + H ₂ O

Bonds Broken	Bonds formed
C=O(740)	C=N(610)
2N-H (390X2)	2H-O(2X460)

Bonds Broken – Bonds Formed = 1520 – 1530 = -10 kJ mol⁻¹

Carbonyl compounds undergo condensation(elimination-addition) with hydrazine.

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