ANGLO-CHINESE JUNIOR COLLEGE
DEPARTMENT OF CHEMISTRY
Preliminary Examination

CHEMISTRY **8873/01**
Higher 1

Paper 1 Multiple Choice

29 August 2018
1 hour

Additional Materials: Multiple Choice Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, index number and tutorial class on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **12** printed pages.

8873/01/Prelim/18
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ANGLO-CHINESE JUNIOR COLLEGE
Department of Chemistry

[Turn over

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

Which of the following statements is **incorrect**?

A   35.5 g of chlorine gas contains 6.0×10^{23} chlorine atoms.

B   24 dm^3 of hydrogen gas at 20 °C and 1 atm contains 1.2×10^{24} hydrogen atoms.

C   500 cm^3 of 1 mol dm^{-3} aqueous magnesium nitrate contains 3.0×10^{23} nitrate ions.

D   4 g of helium gas contains 6.0×10^{23} helium atoms.

2   Wines often contain a small amount of sulfur dioxide that is added as a preservative. The sulfur dioxide content of a wine is found by the following method:

A 50 cm^3 sample of white wine reacted with 40.0 cm^3 of 0.01 mol dm^{-3} aqueous iodine. The sulfur dioxide in the wine is oxidised to sulfate, SO_4^{2-}, in the process.

$$SO_2 + I_2 + 2H_2O \longrightarrow SO_4^{2-} + 2I^- + 4H^+$$
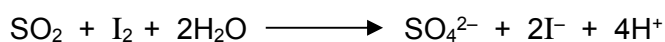
The unreacted iodine requires exactly 23.60 cm^3 of 0.02 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$, for complete reaction.

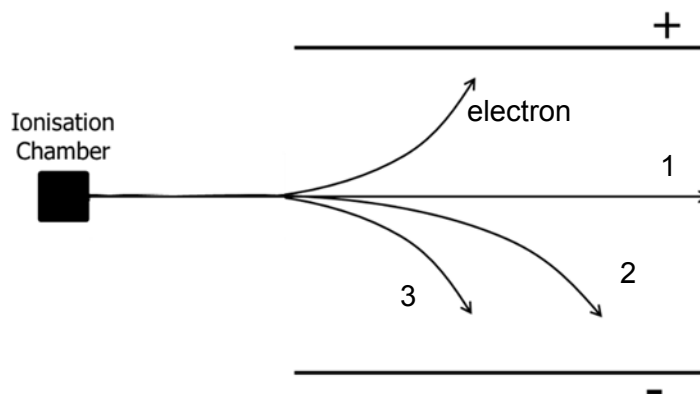What is the concentration of sulfur dioxide, in mol dm^{-3}, in the wine?

A 1.64×10^{-4}
B 3.28×10^{-3}
C 4.72×10^{-3}
D 9.44×10^{-3}

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

$^{243}_{94}$Pu can undergo natural radioactive decay, where one of its electrons enters the nucleus to change a proton into a neutron, to form a new element **M**.

When **M** is put in an ionisation chamber, it emits a high energy α-particle (which is a ^{4}He nucleus).

What is the identity of the element **M** and the path of the emitted α-particle in an electric field?

	chemical symbol of **M**	path of α–particles
A	$^{243}_{93}$**M**	2
B	$^{243}_{95}$**M**	1
C	$^{244}_{93}$**M**	2
D	$^{244}_{95}$**M**	3

4 Which of the following species has more protons than neutrons, and more electrons than protons?

A He^+

B CO

C OH^-

D F^-

5 Trimethoprim (TMP) is used for the treatment of urinary tract infections. It has the following structure:
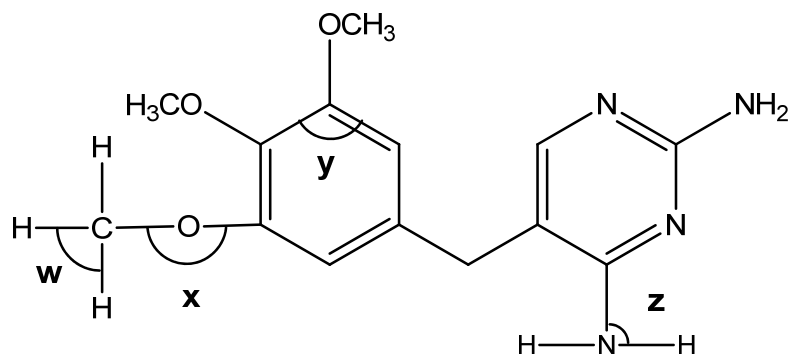
In which sequence are the bond angles **w**, **x**, **y** and **z** quoted in decreasing order?

A   y > w > z > x

B   x > z = y > w

C   y > w > x > z

D   x > z > y > w

6 What is the reason of the difference in bond angle in the molecule of ammonia and water?

A   the number of lone electron pairs in the molecule

B   a bonding electron pair having greater repulsive force than a lone electron pair

C   a greater repulsion between the hydrogen atoms in the longer N–H bond length

D   a greater repulsion between the hydrogen atoms in the shorter O–H bond length

7 When 1.50 g of propan–1,2,3–triol, $C_3H_8O_3$, (M_r = 92.0) was burnt, it was found that 100 g of water was heated from 25 °C to 67 °C. This process was found to have an efficiency of 80%.

What is the magnitude for the enthalpy change of combustion of propan–1,2,3–triol in kJ mol^{-1}?

The specific heat capacity of water is 4.2 J g^{-1} K^{-1}.

A   866

B   879

C   1350

D   1370

8 Phosphine reacts with hydrogen iodide to form phosphonium iodide in the reaction shown.
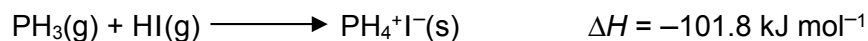
$$PH_3(g) + HI(g) \longrightarrow PH_4^+I^-(s) \qquad \Delta H = -101.8 \text{ kJ mol}^{-1}$$

Given that ΔH_f for PH_3 = +5.4 kJ mol^{-1}, and ΔH_f for HI = +26.5 kJ mol^{-1}, what is the standard enthalpy change of formation of phosphonium iodide?

A   -133.7 kJ mol^{-1}

B   -69.9 kJ mol^{-1}

C   +133.7 kJ mol^{-1}

D   +69.9 kJ mol^{-1}

9 The table shows the charge and radius of each of six ions.

| Ion	J^+	L^+	M^{2+}	X^-	Y^-	Z^{2-}
radius / nm	0.14	0.18	0.15	0.14	0.18	0.15

The ionic solids **JX**, **LY** and **MZ** are of the same lattice type.

What is the correct order of their lattice energies, placing the least exothermic first?

A   **JX, LY, MZ**

B   **JX, MZ, LY**

C   **LY, JX, MZ**

D   **LY, MZ, JX**

10   The graph shows the results of an investigation of the initial rate of hydrolysis of maltose by the enzyme amylase. In the experiments, the initial concentration of maltose is varied but that of amylase is kept constant.
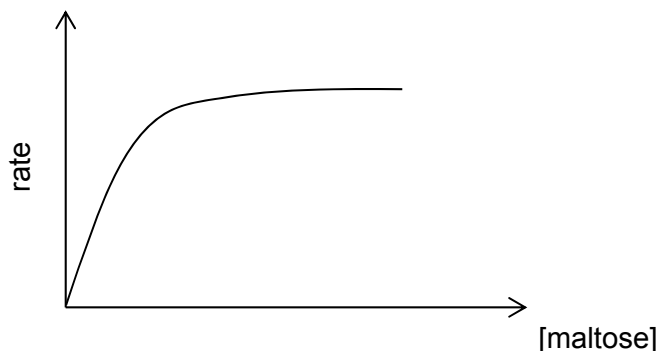

Which of the following **cannot** be deduced from the above information?

1   When [maltose] is low, the rate is first order with respect to maltose.

2   When [maltose] is high, the rate is zero order with respect to maltose.

3   When [maltose] is high, the rate is zero order with respect to amylase.

A   2 only   **B**   3 only   **C**   1, 2 and 3   **D**   1 and 2 only

11   The decomposition $2N_2O_5 \longrightarrow 4NO_2 + O_2$ is first order with respect to N_2O_5.

In an experiment, 0.10 mol of pure N_2O_5 was in an evacuated flask. It was found that there was 0.025 mol of N_2O_5 left after x minutes.

Which of the following statement is true?

A   The half–life of N_2O_5 is $\dfrac{x}{2}$ minutes.

B   The time taken for 0.20 mol of N_2O_5 to reduce to 0.10 mol is x minutes.

C   The half-life is not constant for the decomposition of 0.40 mol of N_2O_5.

D   There was 0.0125 mol of N_2O_5 left after 2x minutes.

12   A catalytic converter is part of the exhaust system of modern cars.
     Which reaction does **not** occur in a catalytic converter?

A $2C_xH_y + (4x + y)NO \longrightarrow 2xCO_2 + yH_2O + (2x + \frac{y}{2})N_2$

B $C_xH_y + (x + \frac{y}{4})O_2 \longrightarrow xCO_2 + \frac{y}{2}H_2O$

C $2CO + 2NO \longrightarrow 2CO_2 + N_2$

D $CO_2 + NO \longrightarrow CO + NO_2$

13 Which of the following statements is true about dynamic equilibrium?

    A All of the reactants are used up.

    B The reactants have stopped reacting.

    C The concentrations of the reactants and products are equal.

   **D** The rate of the forward reaction is equal to the rate of the backward reaction.

14 An equilibrium can be represented by the following equation:
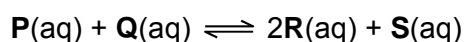
$$\mathbf{P}(aq) + \mathbf{Q}(aq) \rightleftharpoons 2\mathbf{R}(aq) + \mathbf{S}(aq)$$

The total volume of the reaction mixture is 1 dm^3 and the equilibrium concentration of **Q** is 0.8 mol dm^{-3}.

What will the new equilibrium concentration of **Q** be if 0.4 moles of **Q** is completely dissolved in the mixture?
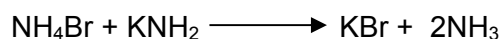
    A 1.2 mol dm^{-3}

    B between 0.8 mol dm^{-3} and 1.2 mol dm^{-3}

    C 0.8 mol dm^{-3}

    D between 0.4 mol dm^{-3} and 0.8 mol dm^{-3}

15 Propanoic acid is used in baked products to inhibit the growth of mould. Propanoic acid, when dissolved in water, dissociates according to this equation:

$$CH_3CH_2CO_2H(aq) \rightleftharpoons CH_3CH_2CO_2^-(aq) + H^+(aq)$$
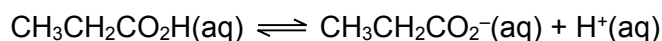
Which of the following statement about propanoic acid is correct?

    A Adding NaOH will have no effect on the amount of propanoic acid that is dissociated.

    B 0.1 mol dm^{-3} of propanoic acid will have a pH of 1.

    C The Brønsted-Lowry conjugate base of propanoic acid is the $CH_3CH_2CO_2^-$ ion.

    D Increasing the concentration of propanoic acid will increase the K_c value.

16 Under appropriate conditions, NH_4Br and KNH_2 react as follows:

$$NH_4Br + KNH_2 \longrightarrow KBr + 2NH_3$$

How is the reaction best classified?

A disproportionation

B acid-base

C redox

D condensation

17 The ionic product of water, K_w at $10\,^{\circ}C$ is $2.93 \times 10^{-15}\,mol^2\,dm^{-6}$.

What is the pH of a solution containing $0.02\,mol\,dm^{-3}$ of strong base $Ba(OH)_2$ at $10\,^{\circ}C$?

A 12.6 **B** 12.9 **C** 13.1 **D** 13.3

18 Given that a $0.500\,mol\,dm^{-3}$ of HNO_2 solution has a K_a value of 7.1×10^{-4}, what is the percentange of **undissociated** HNO_2 molecules?

$$HNO_2 \rightleftharpoons H^+ + NO_2^-$$

A 1.88 % **B** 3.77 % **C** 96.2 % **D** 98.1 %

19 Which of the following oxide is unlikely to react with aqueous sodium hydroxide?

A magnesium oxide

B aluminium oxide

C phosphorus pentoxide

D sulfur trioxide

20 Which of the following elements form an oxide with a giant covalent structure and a chloride which is readily hydrolysed?

A magnesium

B sodium

C phosphorus

D silicon

21 Which statements are true about the elements in Group 1 of the Periodic Table?

1 Their ionic radii increase down the group.

2 They are reducing agents.

3 Their electronegativities decrease down the group.

A 2 and 3 only   **B** 1 and 3 only   **C** 1, 2 and 3   **D** 1 only

22 Which statements about Group 17 elements and the hydrogen halides are correct?

1 Thermal stability of hydrogen halides decreases down the group.

2 Oxidising power of the halogens decreases down the group.

3 Iodine is insoluble in organic solvents.

A 2 and 3 only   **B** 1 and 2 only   **C** 1, 2 and 3   **D** 1 only

23 Which compound reacts with its oxidised product (an oxidation which involves no loss of carbon) to give a sweet-smelling liquid?

A propanal

**B** propanoic acid

C propanone

D propan-1-ol

24 Which property does the compound produced by the addition of liquid bromine to propene have?

1 It can exist as a pair of cis-trans isomers.

2 It possesses permanent dipole-permanent dipole interactions between molecules.

3 It is planar.

A 2 only   **B** 1 and 3 only   **C** 1, 2 and 3   **D** 3 only

25 Why does the reaction $CH_3CH_2X + OH^- \rightarrow CH_3CH_2OH + X^-$ take place more rapidly in aqueous solution when X is changed from Br to I?

A The I^- ion is a stronger reactant than the Br^- ion.

B The I^- ion is less hydrated than the Br^- ion.

C The C−Br bond is more polar than the C−I bond.

D The C−Br bond is stronger than the C−I bond.

26 Which one of the following pairs of compounds might be made to combine together under suitable conditions to form a polyamide?

A a mono-amine and a monocarboxylic acid

B a diamine and a monocarboxylic acid

C a diamine and a dicarboxylic acid

D a mono-amine and a dicarboxylic acid

27 Polymerisation of chloroethene gives poly(vinyl chloride) or PVC.

How does the carbon-carbon bond in PVC compare with that of chloroethene?

A longer and stronger

B longer and weaker

C shorter and stronger

D shorter and weaker

28 Which monomer co-polymerises with

$$CH=CH_2$$

to give a polymer with the repeat unit shown below?

$$-CH-CH_2-CH_2-CH=CH-CH_2-$$

A
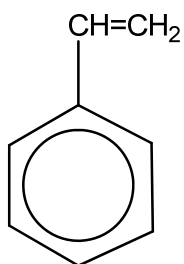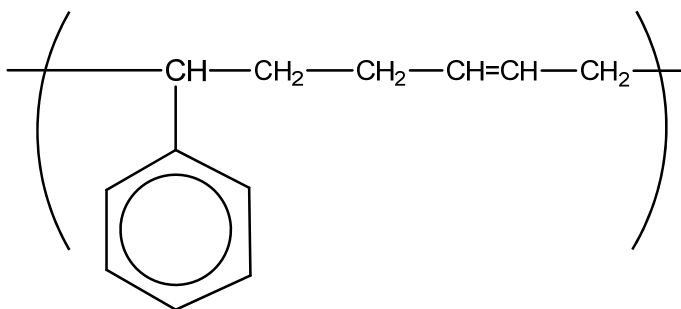
$$H_3C-C(CH_3)=CH_2$$

B $CH_3-CH=CH-CH_3$

C $CH_2=CH-CH_2-CH_3$

D $CH_2=CH-CH=CH_2$

29 Which of the following statements are **incorrect**?

1 Graphene has low tensile strength.

2 Geckos are able to stick to walls as they form strong covalent bonds to the walls.

3 Catalytic converters have a honeycomb structure to maximize the surface area available for catalysis to take place.

A 1 and 2 only   **B** 1 and 3 only   **C** 1, 2 and 3   **D** 1 only

30   What is the maximum size, in at least one dimension, of a nanomaterial?

A 1×10^{-6} m

B 1×10^{-7} m

C 1×10^{-8} m

D 1×10^{-9} m

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Section A

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

1	C	11	A	21	C
2	B	12	D	22	B
3	A	13	D	23	D
4	C	14	B	24	A
5	A	15	C	25	D
6	A	16	B	26	C
7	C	17	C	27	B
8	B	18	C	28	D
9	C	19	A	29	A
10	B	20	D	30	B

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

Which of the following statements is **incorrect**?

A   35.5 g of chlorine gas contains 6.0×10^{23} chlorine atoms.

B   24 dm^3 of hydrogen gas at 20 °C and 1 atm contains 1.2×10^{24} hydrogen atoms.

C   500 cm^3 of 1 mol dm^{-3} aqueous magnesium nitrate contains 3.0×10^{23} nitrate ions.

D   4 g of helium gas contains 6.0×10^{23} helium atoms.

Answer: C

A: n(Cl atoms) = $\dfrac{35.5}{71.0}$ x 2 = 1.0 mol => 6×10^{23} Cl atoms

B: n(H atoms) = $\dfrac{24}{24}$ x 2 = 2.0 mol => $2 \times 6 \times 10^{23}$ H atoms = 1.2×10^{24} H atoms

C: n(NO_3^- ions) = $\dfrac{500}{1000}$ x 1 x 2 = 1.0 mol => 6×10^{23} NO_3^- ions

D: n(He atoms) = $\dfrac{4}{4}$ = 1.0 mol => 6×10^{23} He atoms

2   Wines often contain a small amount of sulfur dioxide that is added as a preservative. The sulfur dioxide content of a wine is found by the following method:

A 50 cm^3 sample of white wine reacted with 40.0 cm^3 of 0.01 mol dm^{-3} aqueous iodine. The sulfur dioxide in the wine is oxidised to sulfate, SO_4^{2-}, in the process.

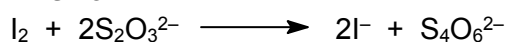$$SO_2 + I_2 + 2H_2O \longrightarrow SO_4^{2-} + 2I^- + 4H^+$$

The unreacted iodine requires exactly 23.60 cm³ of 0.02 mol dm⁻³ sodium thiosulfate, $Na_2S_2O_3$, for complete reaction.

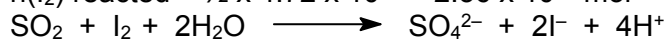What is the concentration of sulfur dioxide, in mol dm⁻³, in the wine?
A 1.64×10^{-4}

B 3.28×10^{-3}

C 4.72×10^{-3}

D 9.44×10^{-3}

Answer: B

$I_2 + 2S_2O_3^{2-} \longrightarrow 2I^- + S_4O_6^{2-}$
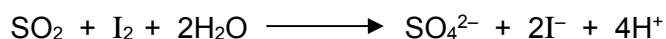
$n(S_2O_3^{2-})$ reacted = $23.60 \times 10^{-3} \times 0.02 = 4.72 \times 10^{-4}$ mol
$n(I_2)$ reacted = ½ $\times 4.72 \times 10^{-4} = 2.36 \times 10^{-4}$ mol
$SO_2 + I_2 + 2H_2O \longrightarrow SO_4^{2-} + 2I^- + 4H^+$
initial $n(I_2) = 40.0 \times 10^{-3} \times 0.01 = 4.00 \times 10^{-4}$ mol
$n(I_2)$ reacted with $SO_2 = 4.00 \times 10^{-4} - 2.36 \times 10^{-4} = 1.64 \times 10^{-4}$ mol
$n(SO_2)$ in wine = $n(I_2)$ reacted = 1.64×10^{-4} mol
$[SO_2]$ in wine = $1.64 \times 10^{-4} / 50 \times 10^{-3} = \underline{3.28 \times 10^{-3}\ mol\ dm^{-3}}$

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

$^{243}_{94}Pu$ can undergo natural radioactive decay, where one of its electrons enters the nucleus to change a proton into a neutron, to form a new element **M**.

When **M** is put in an ionisation chamber, it emits a high energy α-particle (which is a ⁴He nucleus).
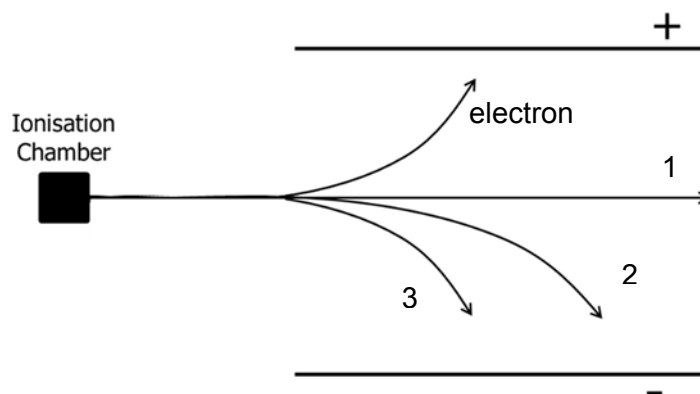
What is the identity of the element **M** and the path of the emitted α-particle in an electric field?

Chemical symbol of **M**	Path of (α–particles)

A	$^{243}_{93}M$	2
B	$^{243}_{95}M$	1
C	$^{244}_{93}M$	2
D	$^{244}_{95}M$	3

Answer: A

$^{243}_{94}Pu$ converts one proton to one neutron to produce $^{243}_{93}M$ as there is no net change in the nucleon number. The emitted alpha particle is the nucleus of ^4He. It has a charge of +2 since there are 2 protons thus it will be deflected towards the negative plate. The charge/mass ratio of the nucleus of ^4He is smaller than that of electron (electron has negligible mass) hence angle of deflection of nucleus of ^4He is smaller.

4   Which of the following species has more protons than neutrons, and more electrons than protons?

A He^+

B CO

C OH^-

D F^-

Answer: C

Species that contain more electrons than protons should be negatively-charged (anions). Hence, options A and B are incorrect.
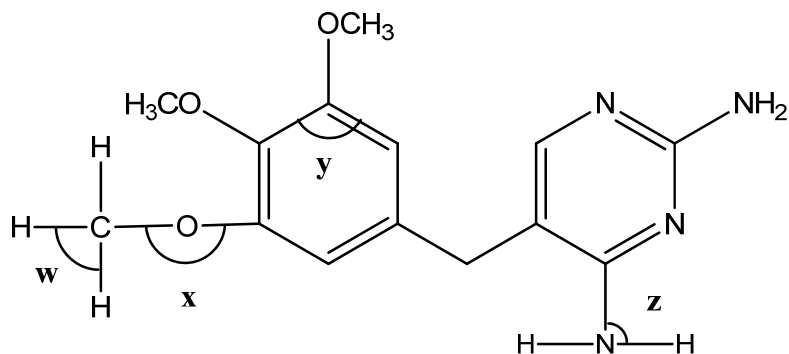
C: Total number of protons = 8 + 1 = 9

   Total number of neutrons = 8 + 0 = 8

D: Total number of protons = 9

   Total number of neutrons = 19 – 9 = 10

5   Trimethoprim (TMP) is used for the treatment of urinary tract infections. It has the following structure:

In which sequence are the bond angles **w**, **x**, **y** and **z** quoted in decreasing order?

A   y > w > z > x

B   x > z = y > w

C   y > w > x > z

D   x > z > y > w

Answer: A

The compression of bond angles depends on the number of lp present.

w: 109.5° (4 bp, 0 lp around sp^3 C)

x: <<109.5° (2 bp, 2 lp around O)

y: 120° (3 bp, 0 lp around sp^2 C)

z: <109.5° (3 bp, 1 lp around N)

Hence, y > w > z > x.

6   What is the reason of the difference in bond angle in the molecule of ammonia and water?

A   the number of lone electron pairs in the molecule

B   a bonding electron pair having greater repulsive force than a lone electron pair

C   a greater repulsion between the hydrogen atoms in the longer N–H bond length

D   a greater repulsion between the hydrogen atoms in the shorter O–H bond length

Answer: A

Recall **VSEPR theory**: Electron pairs around the central atom of a molecule repel each other such that they are as far apart from each other as possible to minimise electron pair repulsion.

$\Rightarrow$ A **lone pair exerts a stronger repulsion than a bond pair** as a lone pair is non–bonding and thus the electron density is closer to the nucleus of the atom.
$\Rightarrow$ Thus, the strength of electrostatic repulsion between electron pairs decreases in the order:
lone pair–lone pair > lone pair–bond pair > bond pair–bond pair

7 When 1.50 g of propan–1,2,3–triol, $C_3H_8O_3$, (M_r = 92.0) was burnt, it was found that 100 g of water was heated from 25 °C to 67 °C. This process was found to have an efficiency of 80%.

What is the magnitude for the enthalpy change of combustion of propan–1,2,3–triol in kJ mol^{-1}?

The specific heat capacity of water is 4.2 J g^{-1} K^{-1}.

A 866
B 879
C 1350
D 1370

Answer: C

heat energy absorbed by the calorimeter (80%) = mcΔT = (100)(4.2)(67 – 25)   =
heat energy produced by the combustion of $C_3H_8O_3$ (100%) = $\frac{100}{80}$(100)(4.2)(42)

n($C_3H_8O_3$) burnt = $\frac{1.5}{92.0}$

Enthalpy change of combustion of $C_3H_8O_3$ = $-\dfrac{(100)(100)(4.2)(42)}{(80)(\frac{1.5}{92})}$ (J mol^{-1})

$= -\dfrac{(10000)(4.2)(42)(92)}{(1000)(80)(1.5)}$ (kJ mol^{-1})

$= -\dfrac{(10)(4.2)(42)(92)}{(80)(1.5)}$ (kJ mol^{-1})

$= -1350$ kJ mol^{-1}

8 Phosphine reacts with hydrogen iodide to form phosphonium iodide in the reaction shown.

$$PH_3(g) + HI(g) \rightarrow PH_4{}^+I^-(s) \qquad \Delta H = -101.8 \text{ kJ mol}^{-1}$$

Given that ΔH_f for PH$_3$ = +5.4 kJ mol^{-1}, and ΔH_f for HI = +26.5 kJ mol^{-1}, what is the standard enthalpy change of formation of phosphonium iodide?

A -133.7 kJ mol^{-1}

B   -69.9 kJ mol^{-1}

C   +133.7 kJ mol^{-1}

D   +69.9 kJ mol^{-1}

Answer: B

$\Delta H_{rxn} = \Delta H_{f(products)} - \Delta H_{f(reactants)}$
$-101.8 = \Delta H_{f(products)} - (+5.4 + 26.5)$
$\Delta H_{f(products)} = \Delta H_f (PH_4I) = -69.9$ kJ mol^{-1}

9   The table shows the charge and radius of each of six ions.

ion	J^+	L^+	M^{2+}	X^-	Y^-	Z^{2-}
radius / nm	0.14	0.18	0.15	0.14	0.18	0.15

The ionic solids JX, LY and MZ are of the same lattice type.

What is the correct order of their lattice energies, placing the least exothermic first?

A   JX, LY, MZ

B   JX, MZ, LY

C   LY, JX, MZ

D   LY, MZ, JX

Answer: C

Since LE $\alpha \dfrac{q^+q^-}{r_+ + r_-}$ and charge of ions is the dominant factor, you should expect the ionic compound formed from M^{2+} and Z^{2-} to have the most exothermic LE.

JX and LY have the same charge on the cation and anion but the lattice energy of JX is more exothermic than LY because it has a smaller ionic radius of the cation and anion

10   The graph shows the results of an investigation of the initial rate of hydrolysis of maltose by the enzyme amylase. In the experiments, the initial concentration of maltose is varied but that of amylase is kept constant.
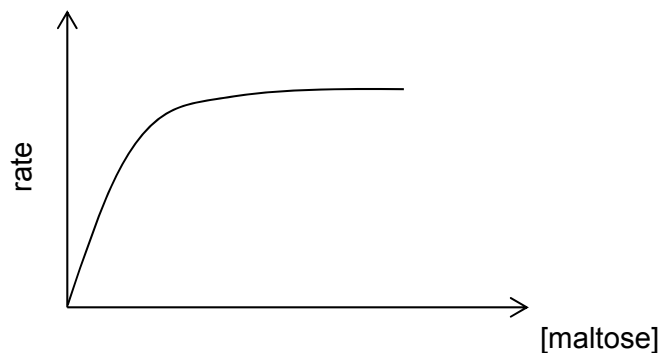
Which of the following **cannot** be deduced from the above information?

1   When [maltose] is low, the rate is first order with respect to maltose.
2   When [maltose] is high, the rate is zero order with respect to maltose.
3   When [maltose] is high, the rate is zero order with respect to amylase.

A   2 only   **B**   3 only   **C**   1, 2 and 3   **D**   1 and 2 only

Answer: B
Option 1: is correct. When [maltose] is low, rate increases (a straight line graph passing through origin is obtained). Hence rate is <u>first order with respect to maltose</u>.
Option 2: is correct. When [maltose] is high, rate remains constant (horizontal straight line
Option 3: There is <u>insufficient information</u> to conclude. In general, enzymes concentrate the reactant molecules (i.e. maltose in this case) by forming temporary bonds with them and thus providing an alternative pathway with lower E_a for the reactants to react. From above, when the [maltose] is high, the rate is <u>more likely</u> to be dependent on the [amylase] (enzyme) as amylase is now the "limiting factor"..

11   The decomposition $2N_2O_5 \longrightarrow 4NO_2 + O_2$ is first order with respect to N_2O_5.

In an experiment, 0.10 mol of pure N_2O_5 was in an evacuated flask. It was found that there was 0.025 mol of N_2O_5 left after x minutes.

Which of the following statement is true?

A   The half–life of N_2O_5 is $\dfrac{x}{2}$ minutes

B   The time taken for 0.20 mol of N_2O_5 to reduce to 0.10 mol is x minutes.

C   The half-life is not constant for the decomposition of 0.40 mol of N_2O_5.

D   There was 0.0125 mol of N_2O_5 left after 2x minutes.

Answer: A

rate = k [N_2O_5] (1st order reaction)
and time taken for [N_2O_5] to decrease to $\dfrac{1}{4}$ [N_2O_5]$_{original}$ = x min

A   is correct. Hence, time taken for [H_2O_2] to decrease to $\dfrac{1}{2}$ [N_2O_5]$_{original}$ = $\dfrac{1}{2}$ x min

B   is incorrect. <u>Half–life is independent of the [reactant]</u> for a 1st order reaction. Hence the time taken would still be $\dfrac{1}{2}$ x min.

C   Half-life should be constant even if initial concentration of reactant is not the same.

D   time taken for [N_2O_5] to decrease to $\dfrac{1}{8}$ [N_2O_5]$_{original}$ will be $\underline{\dfrac{3}{2}$ x min}.

12   A catalytic converter is part of the exhaust system of modern cars.
Which reaction does **not** occur in a catalytic converter?

A $2C_xH_y + (4x + y)NO \longrightarrow 2xCO_2 + yH_2O + (2x + \frac{y}{2})N_2$

B $C_xH_y + (x + \frac{y}{4})O_2 \longrightarrow xCO_2 + \frac{y}{2}H_2O$

C $2CO + 2NO \longrightarrow 2CO_2 + N_2$

D $CO_2 + NO \longrightarrow CO + NO_2$
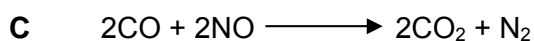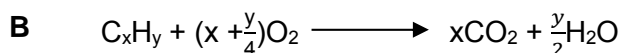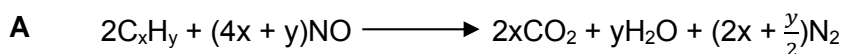
Answer: D

In the catalytic converter, air pollutants such as carbon monoxide, unburnt hydrocarbons and nitrogen oxides are converted to non-polluting products such as carbon dioxide, water and nitrogen.

Options A, B & C – Unburnt hydrocarbons (C_xH_y) are converted to CO_2 and H_2O while NO is converted to N_2 and CO is converted to CO_2.

Option D – Both CO and NO_2 are air pollutants and should not be formed.

13   Which of the following statements is true about dynamic equilibrium?

A   All of the reactants are used up.

B   The reactants have stopped reacting.

C   The concentrations of the reactants and products are equal.

**D**   The rate of the forward reaction is equal to the rate of the backward reaction.

Answer: D

A   False because reactants and products will exist together when dynamic equilibrium is achieved.

B   False. The reactants will continue to form products and the products are also forming reactants.

C   False. The concentrations of the reactants and products remain constant but are not equal to each other.

14   An equilibrium can be represented by the following equation:
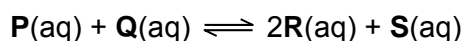
$$P(aq) + Q(aq) \rightleftharpoons 2R(aq) + S(aq)$$

The total volume of the reaction mixture is 1 dm^3, and the equilibrium concentration of **Q** is 0.8 mol dm^{-3}.

What will the new equilibrium concentration of **Q** be if 0.4 moles of **Q** is completely dissolved in the mixture?

A   1.2 mol dm^{-3}

B   Between 0.8 mol dm^{-3} and 1.2 mol dm^{-3}

C   0.8 mol dm^{-3}

D   Between 0.4 mol dm^{-3} and 0.8 mol dm^{-3}

Answer: B

At the point of addition, the concentration of **Q** is 0.8 + 0.4 = 1.2 mol dm^{-3}

However, according to LCP, some of the **Q** added will react to form the products **R** and **S**, thus removing **Q**. The amount of **Q** removed would not be more than the amount that has been added, thus the new equilibrium concentration would be between between 0.8 mol dm^{-3} and 1.2 mol dm^{-3}.

15   Propanoic acid is used in baked products to inhibit the growth of mould. Propanoic acid, when dissolved in water, dissociates according to this equation:

$$CH_3CH_2CO_2H \text{ (aq)} \rightleftharpoons CH_3CH_2CO_2^- \text{ (aq)} + H^+ \text{(aq)}$$
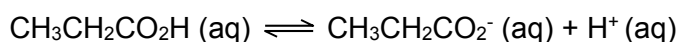
Which of the following statement about propanoic acid is correct?

A   Adding NaOH will have no effect on the amount of propanoic acid that is dissociated.

B   0.1 mol dm^{-3} of propanoic acid will have a pH of 1.

C   The Brønsted-Lowry conjugate base of propanoic acid is the $CH_3CH_2CO_2^-$ ion.

D   Increasing the concentration of propanoic acid will increase the K_c value.

Answer: C

A: Adding NaOH will react with H$^+$ and hence shift the position of equilibrium forward.

B: 0.1 mol dm^{-3} of propanoic acid will have a pH > 1 because propanoic acid is weak and hence [H$^+$] < [CH$_3$CH$_2$CO$_2$H]

D: K_c is only affected by changes in temperature.

16   Under appropriate conditions, NH$_4$Br and KNH$_2$ react as follows:
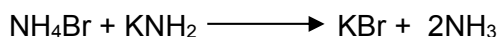
$$NH_4Br + KNH_2 \longrightarrow KBr + 2NH_3$$

How is the reaction best classified?

A   Disproportionation

B   acid-base

C   Redox

D   condensation

Answer: B

NH$_4^+$ is an acid, it donates proton to form NH$_3$. NH$_2^-$ is a base and accepts proton to

from NH_3.

17 The ionic product of water, K_w at 10 °C is 2.93 x 10^{-15} mol^2 dm^{-6}.

What is the pH of a solution containing 0.02 mol dm^{-3} of strong base $Ba(OH)_2$ at 10 °C?

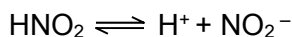**A**   12.6   **B**   12.9   **C**   13.1   **D**   13.3

Answer: C

$Ba(OH)_2 \rightarrow Ba^{2+} + 2OH^-$

$[OH^-] = 2 \times 0.02 = 0.04$ mol dm^{-3}

$pOH = -\log [OH^-] = -\log 0.04 = 1.3979$

$pKw = -\log Kw = -\log (2.93 \times 10^{-15}) = 14.533$

$pH = 14.533 - pOH = 14.533 - 1.3979 = 13.1$

18 Given that a 0.500 mol dm^{-3} of HNO_2 solution has a K_a value of 7.1 x 10^{-4}, what is the percentange of **undissociated** HNO_2 molecules?

$$HNO_2 \rightleftharpoons H^+ + NO_2^-$$

A   1.88 %   **B**   3.77 %   **C**   96.2 %   **D**   98.1 %

Answer: C

$[H^+] = (7.1 \times 10^{-4} \times 0.5)^{1/2} = 0.0188$ mol dm^{-3}

Percentage of undissociated HNO_2 molecules $= 0.5 - [H^+]/ [HA]$

$= (0.5 - 0.0188/ 0.5) \times 100\% = 96.2\%$

19 Which of the following oxide is unlikely to react with aqueous sodium hydroxide?

A   magnesium oxide

B   aluminium oxide

C   phosphorus pentoxide

D   sulfur trioxide

Answer: A

MgO is basic, Al_2O_3 is amphoteric and will react with both acids and bases

P_4O_{10} and SO_3 are both acidic and will react with aq NaOH.

20 Which of the following elements form an oxide with a giant covalent structure and a chloride which is readily hydrolysed?

A   magnesium

B   sodium

C   phosphorus

D   silicon

Answer: D

SiO_2 is giant covalent and $SiCl_4$ is readily hydrolysed to form HCl.

21 Which statements are true about the elements in Group 1 of the Periodic Table?

1   Their ionic radii increase down the Group.

2   They are reducing agents.

3   Their electronegativities decrease down the Group.

A   2 and 3 only   **B**   1 and 3 only   **C**   1, 2 and 3   **D**   1 only

Answer: C
Option 1 is correct as the ionic radii increase down the group due to the increase in number of quantum shells
Option 2 is correct as they are reducing agents as they are able to be oxidised easily by losing electrons. Na forms Na^+ easily.
Option 3 is correct as you go down the group, electronegativity will decrease due to the increase in number of quantum shells, distance between protons and valence electrons increase, valence electrons are less strongly attracted to the nucleus, it is harder for electrons to be attracted.

22 Which statements about Group 17 elements and the hydrogen halides are correct?

1   Thermal stability of hydrogen halides decreases down the group.

2   Oxidising power of the halogens decreases down the group.

3   Iodine is insoluble in organic solvents

A   2 and 3 only   **B**   1 and 2 only   **C**   1, 2 and 3   **D**   1 only
Answer: B
Option 1 is correct as the H-X bond is longer and weaker. Less energy needed to break the H-X bond. Hence the thermal stability decreases down the group.
Option 2 is correct as the ability to be reduced decreases down the group. It is less easily reduced as it is less able to accept electrons. As the atomic size increases, the attraction of the nucleus for an electron also decreases.
Option 3 is incorrect as iodine forms id-id interactions with organic solvents hence it is soluble.

23 Which compound reacts with its oxidised product (an oxidation which involves no loss of carbon) to give a sweet-smelling liquid?

A   propanal

B   propanoic acid

C   propanone

D   propan-1-ol

Answer: D

Propan-1-ol will oxidise to form propanoic acid. The carboxylic acid will react with the alcohol to form an ester, a sweet-smelling liquid.

24 Which property does the compound produced by the addition of liquid bromine to propene have?

1 It can exist as a pair of cis-trans isomers.

2 It possesses permanent dipole-permanent dipole interactions between molecules.

3 It is planar.

A 2 only **B** 1 and 3 only **C** 1, 2 and 3 **D** 3 only

Answer: A
Option 1: Propene reacts with bromine to form 1,2-dibromopropane. Hence there is no cis-trans isomerism,
Option 2: The product 1,2-dibromopropane is a polar molecule and there are pd-pd interactions between molecules.
Option 3: 1,2-dibromopropane is tetrahedral about each carbon atom as each carbon has 4 single bonds.

25 Why does the reaction $CH_3CH_2X + OH^- \rightarrow CH_3CH_2OH + X^-$ take place more rapidly in aqueous solution when X is changed from Br to I?

A The I^- ion is a stronger reactant than the Br^- ion.

B The I^- ion is less hydrated than the Br^- ion.

C The C–Br bond is more polar than the C–I bond.

D The C–Br bond is stronger than the C–I bond.

Answer: D

As the C-I bond is longer due to the smaller extent of overlap of atomic orbitals, it is weaker than the C-Br bond. Hence the C-I is weaker and more easily broken, the substitution reaction is also faster.

26 Which one of the following pairs of compounds might be made to combine together under suitable conditions to form a polyamide?

A a mono-amine and a monocarboxylic acid

B a diamine and a monocarboxylic acid

C a diamine and a dicarboxylic acid

D a mono-amine and a dicarboxylic acid

Answer: C

Nylon 6,6 is a polyamide and is made from a diacid and a diamine.
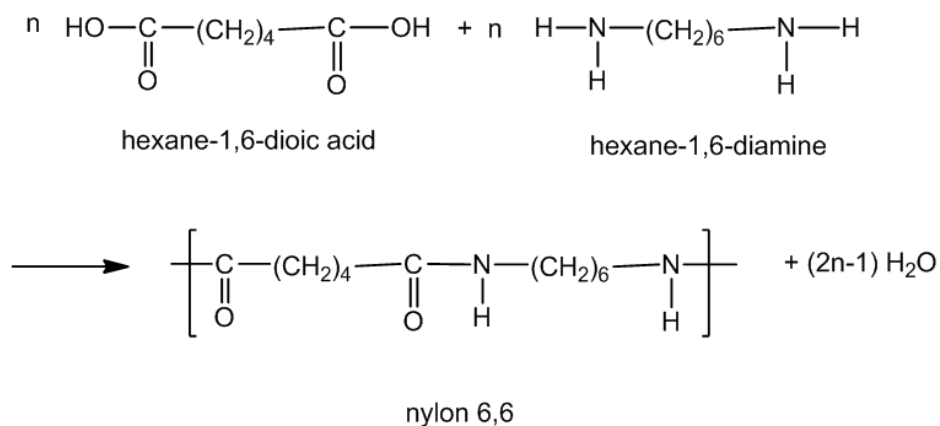
hexane-1,6-dioic acid   hexane-1,6-diamine
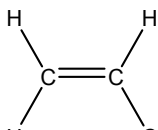

nylon 6,6

27 Polymerisation of chloroethene gives poly(vinyl chloride) or PVC.
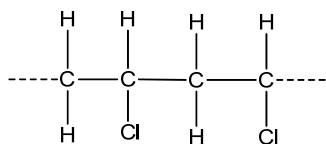
How does the carbon-carbon bond in PVC compare with that of chloroethene?

A   longer and stronger

B   longer and weaker

C   shorter and stronger

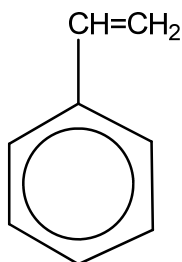**D**   shorter and weaker

Answer: B

For chloroethene: , C is sp^2, C-C bonds are double bonds, C has less p character hence they are shorter and stronger.

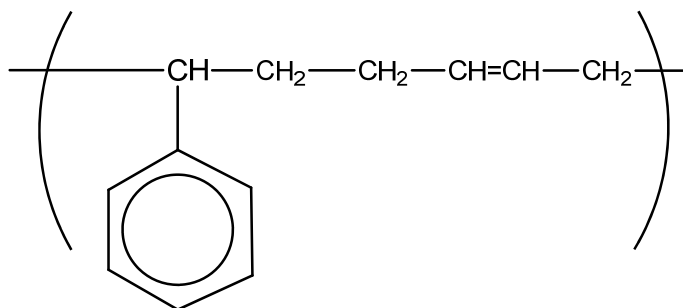For PVC: , C is sp^3, C-C bonds are single bonds, C has higher p character hence the bonds are longer and weaker.
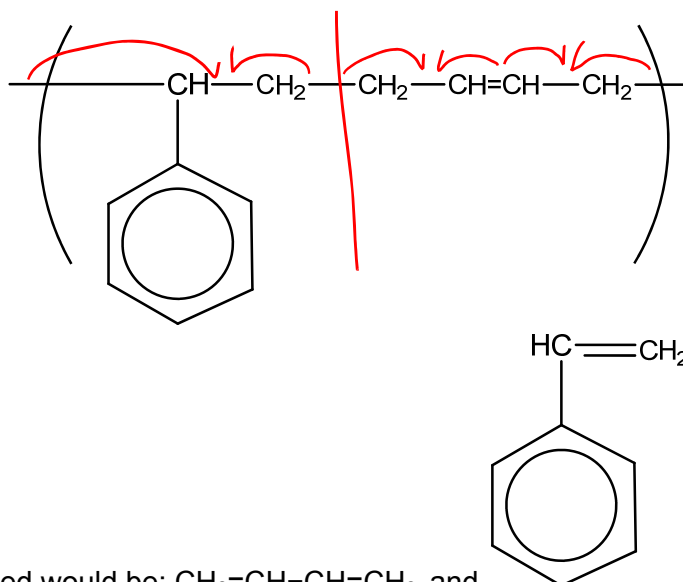
28 Which monomer co-polymerises with

to give a polymer with the repeat unit shown below?

A

B $CH_3-CH=CH-CH_3$

C $CH_2=CH-CH_2-CH_3$

D $CH_2=CH-CH=CH_2$

Answer: D

Monomers formed would be: $CH_2=CH-CH=CH_2$ and

29   Which of the following statements are **incorrect**?

1   Graphene has low tensile strength.

2   Geckos are able to stick to walls as they form strong covalent bonds to the walls.

3   Catalytic converters have a honeycomb structure to maximize the surface area available for catalysis to take place.

A   1 and 2 only   **B**   1 and 3 only   **C**   1, 2 and 3   **D**   1 only

Answer: A
Option 1 is incorrect as it has high tensile strength as each carbon atom has strong

covalent bonds with three other carbon atoms.
Option 2 is incorrect as they form instantaneous dipole- induced dipole interactions with the wall.
Option 3 is correct as a honeycombed structure for catalyst in the catalytic converter is used so as to maximise the surface area on which heterogeneous catalysed reactions take place as the metals are very expensive.

30 What is the maximum size, in at least one dimension, of a nanomaterial?

A 1×10^{-6} m

B 1×10^{-7} m

C 1×10^{-8} m

D 1×10^{-9} m

Answer: **B**

Maximum size = 100 nm = 100×10^{-9} m = 1×10^{-7} m