TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

H1 CHEMISTRY **8873/01**

Paper 1 Multiple Choice **19 September 2024**

1 hour

Additional materials: Multiple Choice Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Write your name, class and register number on the Answer Sheet in the spaces provided.

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

Read very carefully the instructions on the use of Answer Sheet.

You are advised to fill in the Answer Sheet as you go along; no additional time will be given for the transfer of answers once the examination has ended.

Use of Answer Sheet

Ensure you have written your name, class register number and class on the Answer Sheet.

Use a **2B** pencil to shade your answers on the Answer Sheet; erase any mistakes cleanly. Multiple shaded answers to a question will not be accepted.

For shading of class register number on the **Answer Sheet**, please follow the given examples:

If your register number is **1**, then shade **01** in the index number column.

If your register number is **21**, then shade **21** in the index number column.

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

A stream of gaseous $^{40}_{20}Ca^{2+}$ charged ions was passed through an electric field between two oppositely charged plates and the Ca^{2+} ions were deflected at an angle of +15.0°.

Under the same electric field, a stream of unknown gaseous $\mathbf{X}^{3-}$ ion was deflected at an angle of −29.0°. What is a possible atomic number of **X**?

A 15 **B** 24 **C** 31 **D** 34

Answer: A

angle of deflection $\propto \frac{q}{m}$ ratio

$\frac{q}{m}$ of $^{40}_{20}Ca^{2+} = \frac{2}{40}$ ➔ +15.0°

$\frac{q}{m}$ of $\mathbf{X}^{3-} = \frac{3}{\text{Ar of X}}$ ➔ −29.0°

$\frac{29}{15} = \frac{\frac{3}{Ar\ of\ X}}{\frac{2}{40}}$

A_r, mass of X = 31. 0

X could be phosphorus with 15 protons and 16 neutrons

2 Which of these statements correctly describes an electron shell with the principal quantum shell number n = 2?

1 A total of 10 electrons can be accommodated in this shell.

2 An orbital from this shell must be dumb-bell in shape.

3 The energy level of the orbitals in this shell is higher than that in n = 1.

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

Answer: D

Only 3 is correct

An orbital in this shell may **either** be spherical or dumb-bell in shape**.**

A total of 8 electrons can be accommodated in this shell.

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

The first ionisation energy of beryllium is greater than the first ionisation energy of boron.

Which factor explains this?

A charge on the nucleus

B distance from the nucleus to the outer electrons

C removal of electron is from a lower energy orbital

D repulsion between electrons in an orbital

Answer: C

Be: $Be(g) \longrightarrow Be^+(g) + e^-$ 1^{st} IE = +900 kJ mol^{-1}

$1s^2\,2s^2\,2p^6\,3s^2 \longrightarrow 1s^2\,2s^2\,2p^6\,3s^1$

B: $B(g) \longrightarrow B^+(g) + e^-$ 1^{st} IE = +799 kJ mol^{-1}

$1s^2\,2s^2\,2p^6\,3s^2\,3p^1 \longrightarrow 1s^2\,2s^2\,2p^6\,3s^2$

Option **A** is incorrect as going from Be to B, nuclear charge increases, which should account for Be having a lower (not greater) 1^{st} IE than B.

Option **B** is incorrect as Be is (atomic radius: 0.112 nm) expected to be larger than B (atomic radius 0.080 nm), and less energy required if this was the case.

Option **C** is correct as the electron in Be is removed from the s orbital which is lower in energy than the p orbital for B, hence more energy required for 1^{st} IE.

Option **D** is incorrect due to inter-electron repulsion would result in lower 1^{st} IE for Be than B if this was the case.

4 Which of the following does **not** contain hydrogen bonding?

A $NH_3(l)$ **B** $NH_4Cl(l)$ **C** $(CH_3)_2NH(l)$ **D** $CH_3CONH_2(l)$

Answer: B

$NH_4Cl(l)$ contains ionic bonding instead of hydrogen bonding. The rest of the structures contain hydrogen bonding.

5 The CO_2 molecule is linear.

What is the number of σ and π bonds present in the molecule?

	σ	π
A	1	3
B	2	2
C	3	1
D	4	0

Answer: B

Each C=O bond in O=C=O comprises of 1 σ and 1 π bonds, hence 2 σ and 2 π present.

6 The table identifies the shape and polarity of four molecules.
Which row is correct?

	molecule	molecular shape	polarity
A	bromine trifluoride	bent	polar
B	phosphorus trichloride	trigonal pyramidal	polar
C	sulfur dichloride	linear	non–polar
D	trifluoromethane	tetrahedral	non–polar

Answer: B

molecule	No of bond pairs (bp) and lone pairs (lp)	molecular shape	polarity
BrF_3	3 bp 2 lp	T-shaped	polar
PCl_3	3 bp 1 lp	trigonal pyramidal	polar
SCl_2	2 bp 2 lp	bent	polar
CHF_3	4 bp 0 lp	tetrahedral	polar

7 The table shows four species with their corresponding physical properties.
Which species does **not** correspond to its description of physical properties?

	species	physical properties
A	copper	high melting point, conducts electricity when solid and when molten
B	silicon dioxide	high melting point, does not conduct electricity in any state
C	aluminium bromide	high melting point, conducts electricity when molten but not when solid
D	phosphorus pentachloride	low melting point, does not conduct electricity in any state

Answer: C

	species	structure
A	Cu	giant metallic
B	SiO_2	giant molecular
C	**$AlBr_3$**	**simple molecular, not giant ionic**, does not conduct electricity in any state
D	PCl_5	simple molecular

8 Which of the following is **not** an acid–conjugate base pair?

A HCl and $NaCl$

B Na_2HPO_4 and H_3PO_4

C H_2O_2 and HO_2^-

D $CH_3CH_2NH_2$ and $CH_3CH_2NH_3Cl$

Answer: B

Acid-conjugate base pair differs by 1 H^+, but HPO_4^{2-} and H_3PO_4 differs by 2 H^+.

9 Which one of the following acid solutions can be used to give an effective buffer solution by partial neutralisation with aqueous NaOH?

A HCOOH

B HCl

C HI

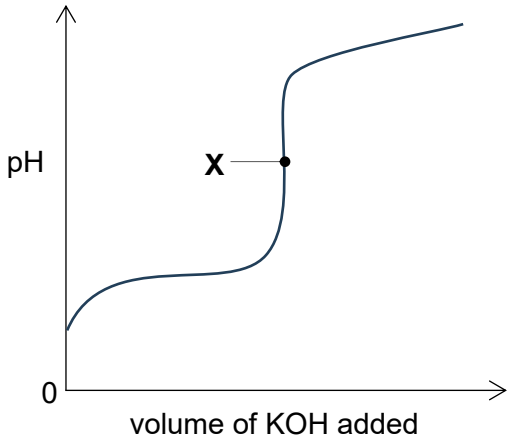
D HNO_3

Answer: A

For an effective acidic buffer, there should be a weak acid and its conjugate base. HCOOH is a weak acid; when partially neutralised, the $HCOO^-$ conjugate base will be present together with HCOOH, giving rise to the buffer.

The other acids are strong acids.

10 The graph shown can be plotted for the titration of aqueous ethanoic acid with potassium hydroxide.



Which species are present in the solution at point **X**?

1 ethanoic acid

2 potassium hydroxide

3 potassium ethanoate

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

Answer: D
Region X is a (basic) salt solution of potassium ethanoate where all the ethanoic acid has been completely neutralised.

11 Which pair of statements is correct for Group 1 elements and their reducing strength?

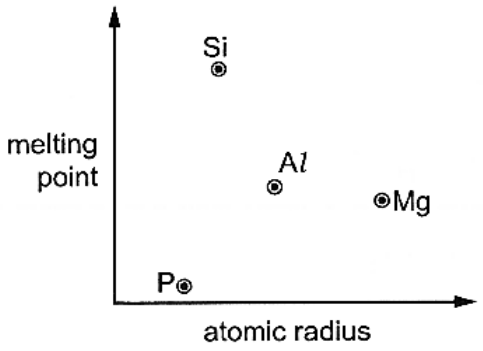
	reducing strength	reason
A	decreases down the Group	valence electron more easily lost
B	decreases down the Group	valence electron more easily gained
C	increases down the Group	valence electron more easily lost
D	increases down the Group	valence electron more easily gained

Answer: C
Down Group 1, nuclear charge increases while number of electron shells and shielding effect increases. Hence reducing strength increases (better reducing agents) as valence electron can be lost more easily (due to weaker electrostatic force of attraction between the electron and the nucleus.

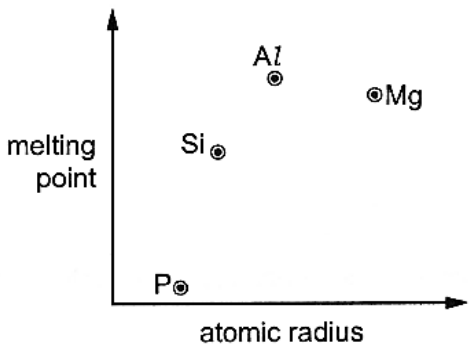
12 *Use of the Data Booklet is relevant to this question.*

Which of the following shows the correct trends when the melting points of the elements, Mg, A*l*, Si and P are plotted against their atomic radii?

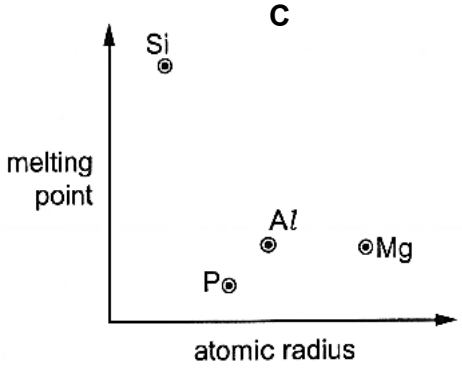
A



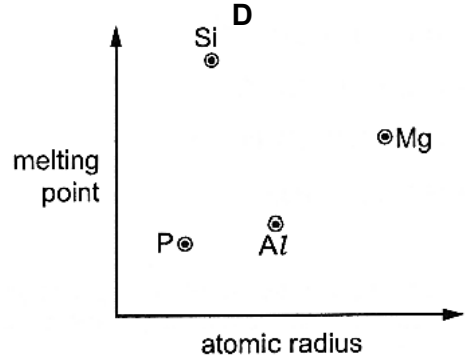
B



C



D



Answer: A

Across the period, from Mg to P,
⇒ Atomic radius decreases.
⇒ **Atomic radii: Mg > A*l* > Si > P** (Option C is wrong.)

Across the period,
⇒ **Si** has the **highest melting point**. (Option B is wrong.)
⇒ **A*l* has a higher melting point than Mg** due to stronger metallic bonds. (Option D is wrong.)

13 Which statement is correct about the halogens (X_2) chlorine, bromine and iodine as well as their corresponding hydrogen halides (HX)?

A The colour intensity of the halogens decreases from Cl_2 to I_2.

B The oxidising power of the halogens decreases from Cl_2 to I_2.

C The thermal stability of HX increases from HC*l* to HI.

D The volatility of HX increases from HC*l* to HI.

Answer: B

The **oxidising power of the halogens decreases down the group** from chlorine to iodine.

14 1 dm^3 of a gaseous hydrocarbon was mixed with excess oxygen. When the mixture undergoes complete combustion, the volume contracted by 2 dm^3. When the resultant mixture was passed through concentrated sodium hydroxide, the gas volume further decreased by 2 dm^3. All volumes were measured at room temperature and pressure.

What is the empirical formula of the hydrocarbon?

A CH
B CH_2
C C_2H_3
D C_3H_4

Answer: B

Since gaseous volume ∝ amounts, put in the coefficients, deducing:

1 $C_xH_y(g)$+ 3 $O_2(g)$→ 2 $CO_2(g)$ + ? $H_2O(l)$

Balancing C atoms, we get x = 2

Balancing O atoms, we find coefficient of H_2O is 2, hence y = 4

Hence, hydrocarbon is C_2H_4 and empirical formula is CH_2.

15 In this question, only V and Zn undergo changes in oxidation numbers.

Vanadium oxide, V_2O_5, reacts with zinc in the presence of acidic medium. Zn is oxidised to Zn^{2+} and 3 moles of Zn react with 1 mole of V_2O_5.

What is the final oxidation number of V in the vanadium containing product of this reaction?

A 0 **B** +1 **C** +2 **D** +3

Answer: C

$Zn \longrightarrow Zn^{2+} + 2e^-$

Initial oxidation number of V in V_2O_5 = + 5

Since 3 Zn ≡ 6 e ≡ V_2O_5

Each V^{5+} takes in 3 e, hence, new oxidation number of V = +2.

16 Chromates such as sodium chromate, Na_2CrO_4, are used in chrome plating to protect metals and can be manufactured by heating iron(II) chromite, $FeCr_2O_4$, with sodium carbonate in air.

$$4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \rightarrow 8Na_2CrO_4 + 2Fe_2O_3 + 8CO_2$$

Which species is oxidised and which species is reduced in this process?

	species oxidised	species reduced
A	chromium and iron	carbonate ion and oxygen
B	chromium and iron	oxygen only
C	iron only	carbonate ion only
D	chromium only	carbonate ion and oxygen

Answer: B

Oxygen: Oxidation number changes from 0 in O_2 to –2 in CO_2

Chromium: Oxidation number changes from +3 in $FeCr_2O_4$ to +6 in CrO_4^{2-}.

Iron: Oxidation number changes from +2 in $FeCr_2O_4$ to +3 in Fe_2O_3

17 Substances **X** and **Y** react to form product **Z**.

$$2\mathbf{X} + \mathbf{Y} \rightarrow 2\mathbf{Z}$$

The reaction was studied and the following data were obtained:

experiment	[**X**] / mol dm^{-3}	[**Y**] / mol dm^{-3}	initial rate / mol dm^{-3} min^{-1}
1	0.10	0.10	0.020
2	0.20	0.10	0.080
3	0.15	0.23	0.045

What is the order of reaction with respect to **X** and **Y**?

A First order with respect to **X** and zero order with respect to **Y**.

B Second order with respect to **X** and first order with respect to **Y**.

C First order with respect to **X** and first order with respect to **Y**.

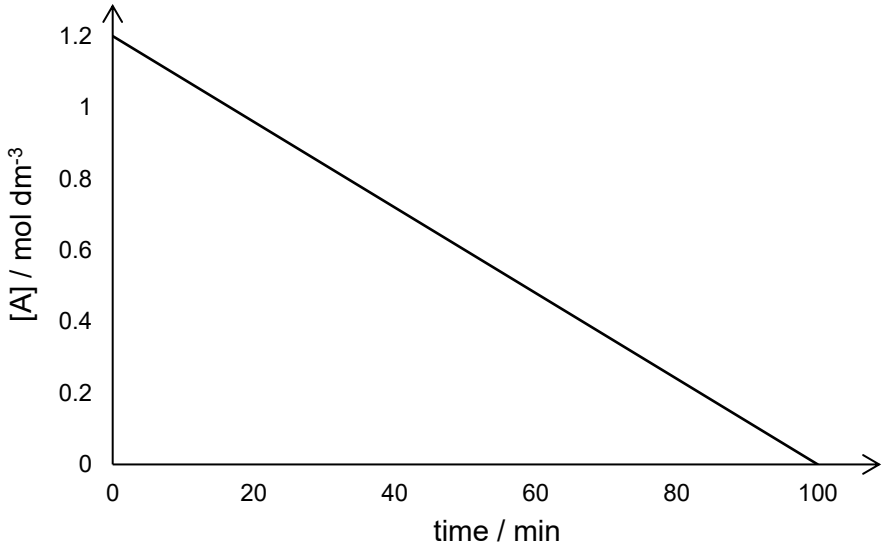
D Second order with respect to **X** and zero order with respect to **Y**.

Answer: D

Compare experiments 1 and 2 to determine the order with respect to **X**:
[**X**] changes from 0.10 to 0.20 (doubles), [**Y**] is constant. Initial rate changes from 0.020 to 0.080 (quadruples) $\Rightarrow$ 2nd order wrt **X**

Compare experiments 1 and 3 to determine the order with respect to **Y**:
[**X**] changes from 0.10 to 0.15 (× 1.5), and since 2nd order wrt X, this will cause the rate to multiply by $(1.5)^2 = 2.25$ times
Initial rate changes from 0.020 to 0.045 (2.25 times) ⇒ change in [**Y**] had no additional effect on initial rate ⇒ zero order wrt **Y**

18 The graph shows the results of decomposition of compound A.



Which conclusions can be drawn from the graph?

1 The half-life of the decomposition of A is constant.
2 The rate of the reaction is independent of the concentration of A.
3 Units of rate constant, *k*, is mol dm^{-3} min^{-1}.

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

Answer: C

From the graph, the rate is constant as gradient is constant. Hence this is a zero order reaction.

Rate is independent of concentration.

Rate = $k [N_2O_4]^0$, hence units of k = mol dm^{-3} min^{-1}

19 A radioactive isotope follows first order kinetics in its decay.

If the rate of decay of a radioactive isotope decreases from 400 counts per minute to 25 counts per minute after 24 hours, what is its half-life?

A 3 hours

B 4 hours

C 6 hours

D 12 hours

Answer: C

400 → 200 → 100 → 50 → 25 (4 x half-lives)

In 24 hours, 4 half-lives have passed, hence duration of each half-life is 6 h.

20 Which equation best represents the enthalpy change of formation of iron (III) oxide, Fe_2O_3?

A $2Fe\,(l) + 3O\,(g) \rightarrow Fe_2O_3\,(s)$

B $4Fe\,(s) + 3O_2\,(g) \rightarrow 2Fe_2O_3\,(s)$

C $2Fe\,(s) + 3O\,(g) \rightarrow Fe_2O_3\,(s)$

D $2Fe\,(s) + 3/2\,O_2\,(g) \rightarrow Fe_2O_3\,(s)$

Answer: D

Elements must be in their natural state, ie. Fe as a solid and oxygen as O_2 in gaseous state to form 1 mole of the compound.

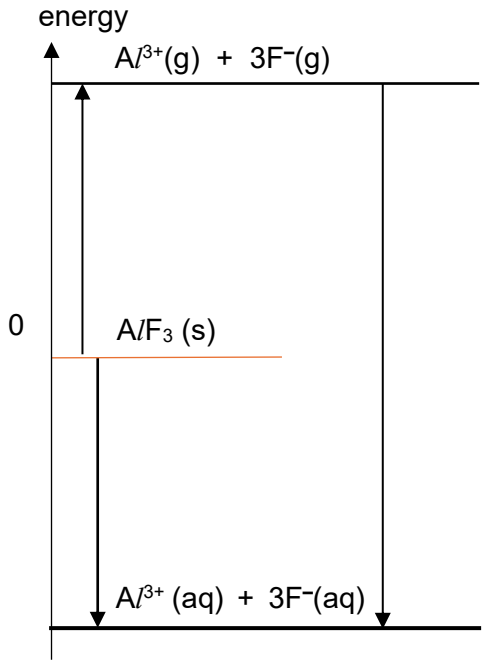
21 The enthalpy change of solution of a solid ionic compound is the energy change when one mole of the substance is completely dissolved in a solvent to form aqueous ions.

The enthalpy change of solution is dependent on:

- lattice energy of the ionic compound,
- hydration energy of the gaseous ions to aqueous ions.

	/ kJ mol^{-1}
Lattice energy of AlF_3	–6083
Enthalpy change of hydration of Al^{3+}	–4750
Enthalpy change of hydration of F^-	–473

Using the energy level diagram and the data provided, determine the enthalpy change of solution of aluminium fluoride, $AlF_3(s)$.



A –86 kJ mol^{-1}

B –860 kJ mol^{-1}

C –11300 kJ mol^{-1}

D –12250 kJ mol^{-1}

Answer: A

Applying Hess' Law, $\Delta H_{sol} = -LE + (\Delta H_{hyd}(Al^{3+}) + (3 \times \Delta H_{hyd}(F^-))$

$= -(-6083) + (-4750 + 3(-473))$

$= -86$ kJ mol^{-1}

22 The following enthalpy changes of the following substances are provided:

	/ kJ mol^{-1}
Standard enthalpy change of combustion of graphite	–394
Standard enthalpy change of formation of water	–286
Standard enthalpy change of formation of liquid ethanol	–277

Calculate the value of standard enthalpy change of combustion of liquid ethanol.

A –403 kJ mol^{-1}
B –957 kJ mol^{-1}
C –1369 kJ mol^{-1}
D –1865 kJ mol^{-1}

Answer: C
Target equation is $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

Note that ΔH_c[C(graphite)] is essentially ΔH_f[CO_2(g)], both based on the equation $C(graphite) + O_2(g) \rightarrow CO_2(g)$

The standard enthalpy change of combustion can be calculated using the formula:
Sum of ΔH_f of products – (sum of ΔH_f of reactants)
$= [(2 \times -394) + (3 \times -286)] - [(-277) + 0] = -1369$ kJ mol^{-1}

23 Consider the following equilibrium reaction:

$$H_2(g) + Cl_2(g) \rightleftharpoons 2HCl(g) \qquad \Delta H < 0$$

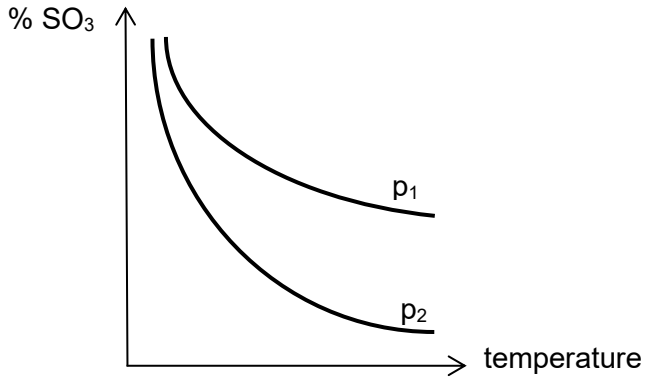
Which of the following changes will decrease the equilibrium yield of HC*l*?

A adding more H_2(g)
B adding a suitable catalyst
C decreasing the volume of the system
D increasing the temperature

Answer: D
A The system will adjust to reduce the concentration of H_2 by shifting the equilibrium to the right, producing more HC*l*(g).
B Catalysts speed up the reaction but do not change the equilibrium yield.
C Decreasing the volume results in an increase in pressure. The equilibrium position will shift to the side with fewer moles of gas. Since this equilibrium reaction has the same number of gases on both sides, increasing pressure has no effect on equilibrium position.
D For an exothermic reaction, increasing the temperature adds heat to the system, causing the equilibrium position to shift to the left to absorb the added heat.

24 The graph below shows how the percentage of $SO_3(g)$ in the equilibrium mixture of Contact Process varies with temperature at different pressures, p_1 and p_2.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H_r$$



Which of the following is correct?

	ΔH_r	pressure
A	exothermic	$p_1 < p_2$
B	exothermic	$p_1 > p_2$
C	endothermic	$p_1 < p_2$
D	endothermic	$p_1 > p_2$

Answer: B

By Le Chatelier's Principle,

- when pressure increases, the equilibrium position will shift right towards less amount of gases, hence % of SO_3 will increase. Thus **p_1 is at a higher pressure than p_2**.
- when temperature increases, the equilibrium position will shift left towards endothermic reaction to absorb heat, hence **% of SO_3 will decrease**. Hence the **forward reaction is exothermic**.

25 A mixture of hydrogen and iodine will form an equilibrium mixture as shown by the equation.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

The table gives the concentration of each substance in a mixture at equilibrium under certain conditions.

substance	concentration / mol dm^{-3}
H_2	0.6
I_2	0.2
HI	0.4

What is the numerical value of K_c under these conditions?

A 0.30

B 0.75

C 1.33

D 3.33

Answer: C

$$K_c = \frac{[HI]^2}{[H_2][I_2]} = \frac{[0.4]^2}{[0.6][0.2]} = \underline{\mathbf{1.33}}$$

26 Properties of graphene make it ideal for making the next-generation optoelectronics and optical communications systems, particularly in making touchscreens, liquid crystal displays (LCD) and organic light emitting diodes (OLEDs).

Which property of graphene is the least essential for its use in touchscreen tablets?

A good electrical conductivity

B high optical transparency

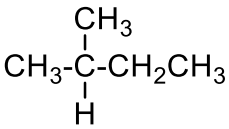
C high tensile strength

D light weight

Answer: C

Fast transmission of data, high light emission and light weight are the key properties in graphene that give it the edge over many other materials. High tensile strength is not essential in this application.

27 When exposed to chlorine gas under UV light, 2-methylbutane formed different mono-chlorinated products.



2-methylbutane

What is the ratio of the mono-chlorinated products formed?

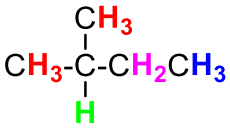
A 7 : 5

B 6 : 5 : 1

C 9 : 2 : 1

D 6 : 3 : 2 : 1

Answer: D



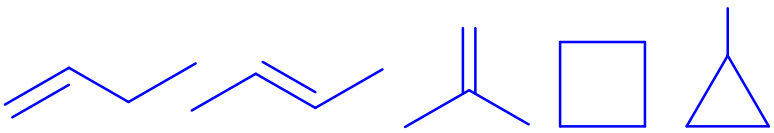
There are 4 different positions the Cl atom can be substituted on. The ratio of the products will be based on the number of hydrogen atoms on each carbon.

Hence the ratio is **6** : **3** : **2** : **1**

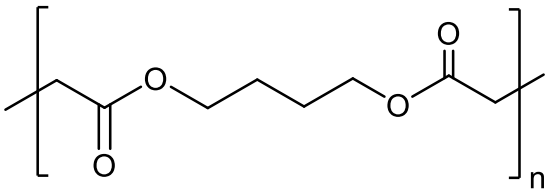
28 What is the total number of constitutional isomers, including ring structures, that has the molecular formula C_4H_8?

A 3 **B** 4 **C** 5 **D** 6

Answer: C



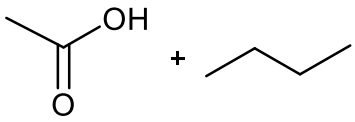
29 Polybutylene succinate (PBS) is a biodegradable polymer which found itself useful in many applications like disposable food packaging and medicine capsules.



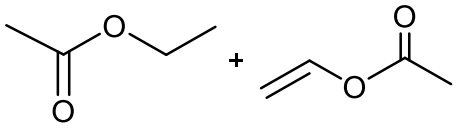
PBS repeating unit

The PBS molecule is made up of two different monomer units. Which of these can be the monomers?

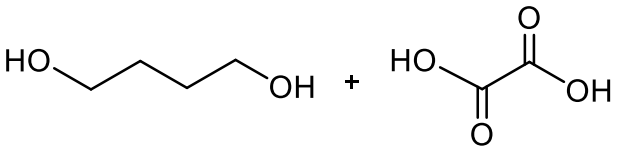
A



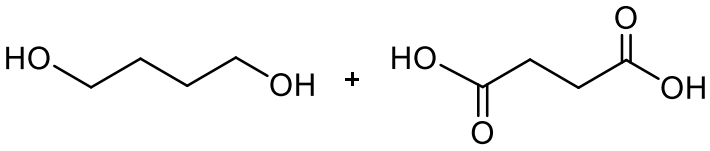
B



C



D

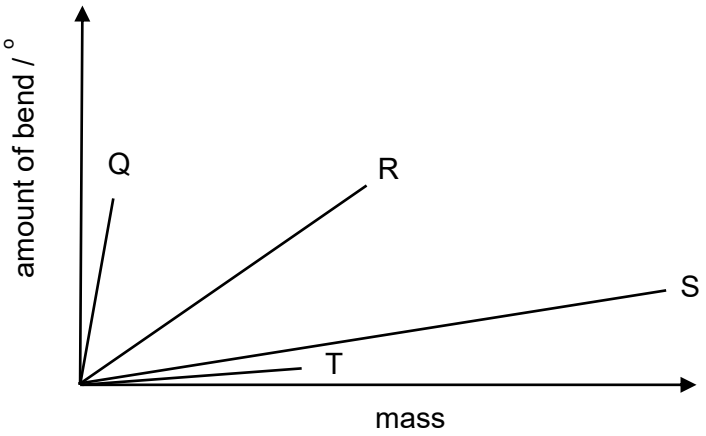


Answer: D

The **ester bonds** in PBS are formed via **condensation polymerisation**, which only Option **D** illustrate the reaction with the correct number of carbons in the monomers.

30 The flexibility and strength of 4 polymers Q to T are measured.

They are first made into sheets. These sheets are supported at opposite ends and masses are added to the centre of the sheets. As the masses are added, the amount the polymer bends, in degrees, is measured until the polymer breaks.



Which conclusions are true?

1 Polymer Q is most suitable for making chairs.

2 Polymer R is likely a thermoplastic.

3 Polymer S is most suitable for making machinery parts.

4 Polymer T is likely a thermosetting plastic.

A 1, 2, 3 and 4 **B** 2, 3 and 4 only **C** 1 and 3 only **D** 2 and 4 only

Answer: B

Option 1 is incorrect as chairs need to be able to hold heavy weights without breaking easily. Hence polymer Q is not suitable.

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