Name:		Centre/Index Number:		Class:	

DUNMAN HIGH SCHOOL
Preliminary Examination
Year 6

H2 CHEMISTRY

9729/01

Paper 1 Multiple Choice

20 September 2024
1 hour

Additional Materials: Multiple Choice Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your centre number, index number, name and class at the top of this page.
Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.

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 **16** printed pages.

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

Which transition metal ions have the same number of unpaired electrons as a phosphorus atom in its ground state?

1 Ti^{2+}

2 V^{2+}

3 Cr^{3+}

A 1 and 2 only

B 2 and 3 only

C 1 and 3 only

D 1, 2 and 3

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

What is the order of decreasing enthalpy change for the reactions shown?

$Si^{+}(g) \rightarrow Si^{2+}(g) + e^{-}$ ΔH_1

$Al^{+}(g) \rightarrow Al^{2+}(g) + e^{-}$ ΔH_2

$Si(g) \rightarrow Si^{2+}(g) + 2e^{-}$ ΔH_3

A $\Delta H_1 > \Delta H_2 > \Delta H_3$

B $\Delta H_2 > \Delta H_3 > \Delta H_1$

C $\Delta H_3 > \Delta H_1 > \Delta H_2$

D $\Delta H_3 > \Delta H_2 > \Delta H_1$

3 Analysis of a mixture of sulfur-containing gases shows that hydrogen sulfide, H_2S, and carbon disulfide, CS_2, are present in a 2 : 1 mole ratio.

The mixture is burned in excess oxygen.

Which row describes:
- the SO_2 : CO_2 mole ratio in the mixture obtained after complete combustion,
- the relative deviation from ideal behaviour of the gases, CO_2 and CS_2?

	SO_2 : CO_2 mole ratio	relative deviation
A	3 : 1	CS_2 deviates more than CO_2
B	4 : 1	CS_2 deviates more than CO_2
C	3 : 1	CO_2 deviates more than CS_2
D	4 : 1	CO_2 deviates more than CS_2

4 The table shows the melting points of two ionic compounds.

compound	melting point / °C
CaO	2613
NaF	993

Which statement helps to explain the relative melting points of CaO and NaF?

A Ca^{2+} has a larger ionic radius than Na^+.

B Ca^{2+} has a higher charge density than Na^+.

C The sum of ionic radii is larger for CaO than NaF.

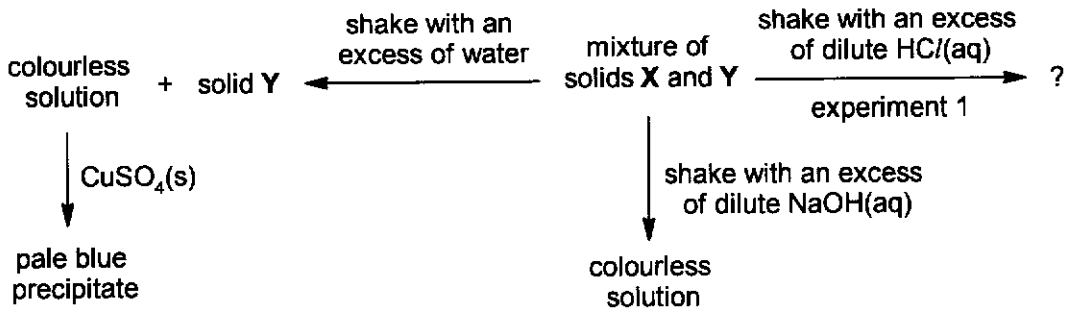
D The ionic charges are larger in magnitude for CaO than NaF.

5 How many of the molecules listed are polar **and** have the same shape?
- NCl_3
- HCN
- $BeCl_2$
- $SOCl_2$

A none **B** 2

C 3 **D** 4

6 A student carries out an investigation using a mixture of Period 3 oxides, **X** and **Y**. All experiments are carried out at room temperature.



Which observation would the student make of the result of experiment 1?

A Colourless solution only

B Colourless solution + solid **X**

C Colourless solution + solid **Y**

D Mixture of solids **X** and **Y**

7 Which statement about the behaviour of Group 2 elements from magnesium to barium is correct?

A The polarising power of the cations increases.

B The oxidising power of the elements increases.

C The covalent character of the metal chlorides increases.

D The thermal stability of the metal carbonates increases.

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

An excess of aqueous chlorine was added to a sample of aqueous potassium bromide in a test-tube.

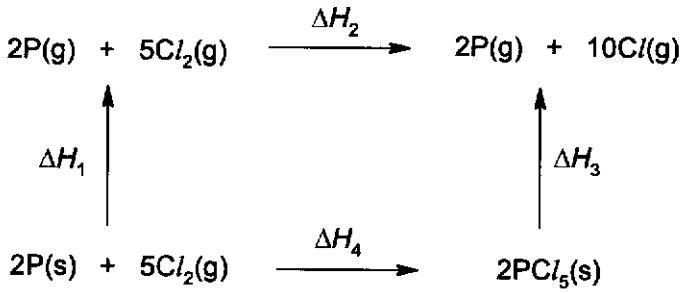
An equal volume of aqueous silver nitrate was then added to the resulting solution.

Which row of observations would be made?

	on adding chlorine	on adding silver nitrate
A	colourless solution remains	cream precipitate formed
B	colourless solution turns orange	cream precipitate formed
C	colourless solution turns orange	white precipitate formed
D	colourless solution turns pale yellow	white precipitate formed

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

The following reactions at 298 K, form an energy cycle.



Which descriptions of the enthalpy changes are correct?

1 $\Delta H_1 + \Delta H_2 > +1220$ kJ mol^{-1}

2 $\Delta H_3 = 10 \times$ P–C*l* bond energy

3 $\Delta H_4 = 2 \times \Delta H^{\ominus}_{formation}$ of $PCl_5(s)$

A 1 and 2 only

B 1 and 3 only

C 2 and 3 only

D 1, 2 and 3

10 For the reaction, $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$, $\Delta H = -92$ kJ mol^{-1}.

Which statement about the forward reaction is correct?

A It is spontaneous only at low temperature.

B It is spontaneous only at high temperature.

C It is not spontaneous at any temperature.

D It is spontaneous at all temperatures.

11 0.02 mol of an iodine oxide reacts with 0.2 mol of acidified potassium iodide to give 0.12 mol of iodine, I_2.

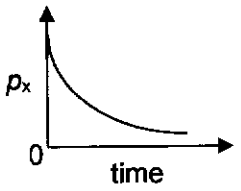
What is the oxidation number of iodine in the oxide?

A +1 **B** +3 **C** +5 **D** +7

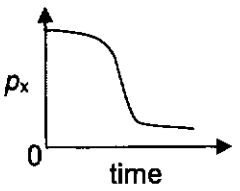
12 An excess of H_2 gas is reacted with Cl_2 gas in a 1 dm^3 vessel at constant temperature. The reaction is catalysed by UV light and is found to be zero order with respect to Cl_2.

Which diagram represents the variation of partial pressure of Cl_2 gas, p_x, with time?

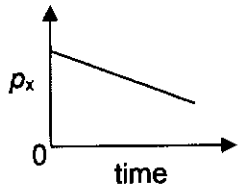
A



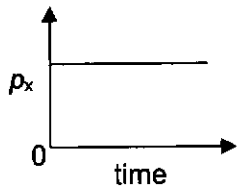
B



C



D



13 The kinetics of the following reaction is studied by finding the time taken for a coloured reactant, **A**, to decolourise. The reaction is catalysed by **Y**.

$$\mathbf{A} + \mathbf{B} \xrightarrow{\mathbf{Y}} \mathbf{C} + \mathbf{D}$$

The following results are obtained:

experiment number	volume of **A** added / cm^3	volume of **B** added / cm^3	volume of **Y** added / cm^3	volume of H_2O added / cm^3	time taken / s
1	10	20	10	10	20
2	10	10	10	20	40
3	10	20	5	15	40
4	5	20	10	15	10
5	2.5	20	10	17.5	?

Which statements about this reaction are correct?

1 Colorimetry can be used to monitor the kinetics of the reaction.

2 The rate equation is rate = k[**B**][**Y**].

3 The time taken for experiment 5 is 5 s.

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

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

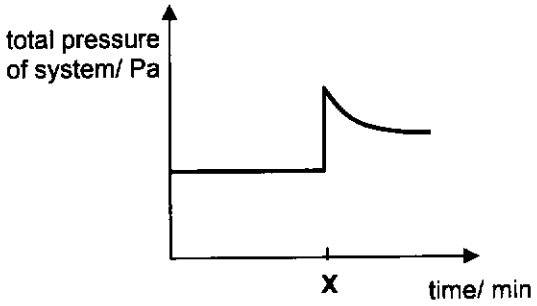
14 **E** and **F** are reacted in a closed vessel to form **G** as shown.

$$E(g) + F(g) \rightleftharpoons G(g)$$

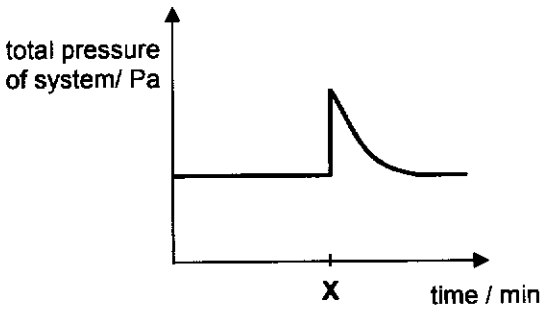
At time **X** min, 1 mol of inert gas **P** is added at constant volume.

Which of the following graphs represents the variation of total pressure of the system with time?

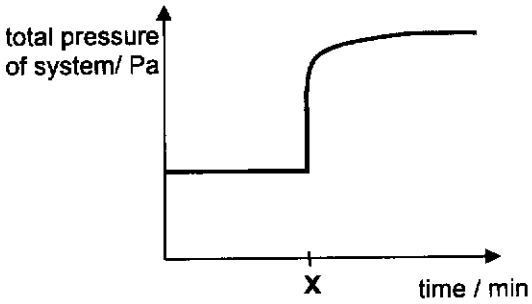
A



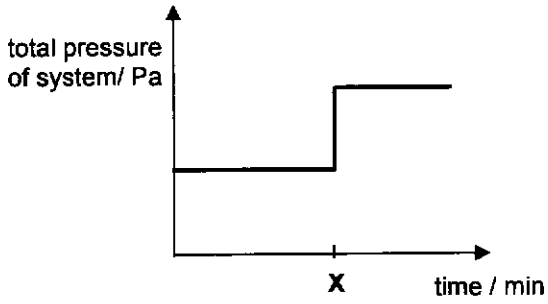
B



C



D



15 A metal hydroxide dissolves partially in water as shown:

$$M(OH)_2(s) + aq \rightleftharpoons M^{2+}(aq) + 2OH^-(aq) \qquad \Delta H > 0$$

Which statements are correct as temperature increases?

1 Equilibrium is reached at a faster rate.

2 pH of the solution increases.

3 K_{sp} of $M(OH)_2$ increases.

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

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

16 Which of the following pairs can be used to prepare a buffer of approximately pH 6 that has maximum buffer capacity?

A	NH_4^+ and NH_3	K_b of NH_3 = 1.78×10^{-5} mol dm^{-3}
B	H_2CO_3 and HCO_3^-	K_b of HCO_3^- = 2.38×10^{-8} mol dm^{-3}
C	H_3PO_4 and $H_2PO_4^-$	K_b of $H_2PO_4^-$ = 1.33×10^{-12} mol dm^{-3}
D	CH_3COOH and CH_3COO^-	K_b of CH_3COO^- = 5.71×10^{-12} mol dm^{-3}

17 A solution contains two anions with the following concentrations:

anion	concentration / mol dm^{-3}
CrO_4^{2-}	0.200
Cl^-	0.0100

Aqueous $AgNO_3$ is slowly added to the solution.

Which is the first compound to precipitate and what concentration of Ag^+ is necessary to begin its precipitation?

Given: $K_{sp}(Ag_2CrO_4) = 1.20 \times 10^{-12}$ mol^3 dm^{-9}, $K_{sp}(AgCl) = 1.80 \times 10^{-10}$ mol^2 dm^{-6}

	first precipitate formed	$[Ag^+]$
A	Ag_2CrO_4	6.00×10^{-12}
B	Ag_2CrO_4	2.45×10^{-6}
C	$AgCl$	1.34×10^{-5}
D	$AgCl$	1.80×10^{-8}

18 Which molecule contains a total of four sp–hybridised carbon atoms?

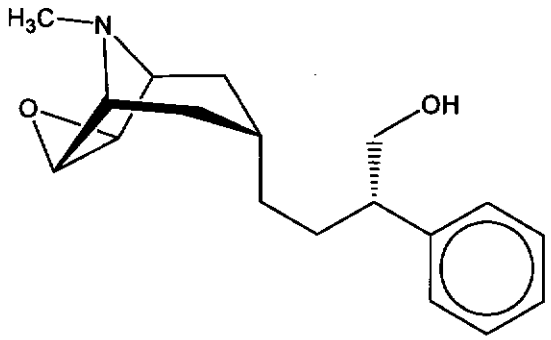
A $HC{\equiv}C\text{-}CH{=}CH\text{-}CH{=}CH_2$

B $H_2C{=}C{=}C{=}CH\text{-}CH{=}CH_2$

C $HC{\equiv}C\text{-}CH{=}CH\text{-}CH{=}CH\text{-}CN$

D $H_2C{=}C{=}C{=}C{=}CH\text{-}CH_2\text{-}CN$

19 Scopolamine is a toxic hallucinogen found naturally in plants such as the deadly nightshade and angels' trumpet.



scopolamine

What is the total number of chiral carbons in this molecule?

A 5 **B** 6

C 7 **D** 8

20 What is the total number of different chloroethanes with the formula $C_2H_{6-n}Cl_n$?
[n can be any integer from 1 to 6]

A 6 **B** 8 **C** 9 **D** 10

21 But-2-ene-1,4-diol is converted in two steps through an intermediate **H** into ketobutanedioic acid.

$$HOCH_2CH{=}CHCH_2OH \xrightarrow[\text{step 1}]{} \mathbf{H} \xrightarrow[\text{step 2}]{\text{hot acidified } KMnO_4} HO_2CCOCH_2CO_2H$$

but-2-ene-1,4-diol — ketobutanedioic acid

What could be the reagent for step 1 and the structure of intermediate **H**?

	reagent for step 1	structure of **H**
A	steam and concentrated H_3PO_4	$HOCH_2CH_2CH(OH)CH_2OH$
B	HBr(g)	$HO_2CCH(OH)CH_2CO_2H$
C	cold acidified $KMnO_4$	$HOCH_2CH(OH)CH(OH)CH_2OH$
D	warm acidified $K_2Cr_2O_7$	$HO_2CCH{=}CHCO_2H$

22 Which of the following reagents and conditions can be used to distinguish between benzene and cyclohexene?

1 Excess hydrogen gas with nickel at high temperature and pressure.

2 Hot acidified potassium manganate(VII).

3 Aqueous bromine, absence of UV light.

A 1 and 2 only

B 1 and 3 only

C 1 only

D 2 and 3 only

23 Chlorofluoroalkanes are commonly used as aerosol propellents. However, they cause depletion to the ozone layer when they rise into the stratosphere. It has thus been suggested that fluoroalkanes should be used instead.

Which of the following could be a possible reason for the suggestion?

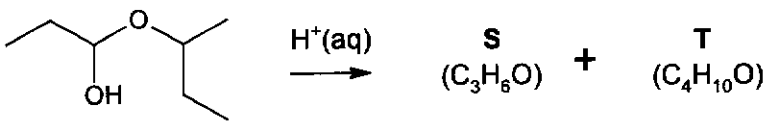
A Fluoroalkanes are less volatile than chlorofluoroalkanes and are less likely to reach the stratosphere.

B Fluorine radicals may be produced, but unlike chlorine radicals, do not react with ozone.

C Fluorine radicals are not produced as the C–F bonds are stronger than the C–C*l* bonds.

D Fluorine radicals may be produced, but unlike chlorine radicals, will not generate more radicals after reacting with ozone.

24 An organic chemist treated compound **R** with a catalytic amount of $H^+(aq)$ to yield compounds **S** and **T**.



R
$(C_7H_{16}O_2)$

How many different isomers will be formed after **T** has been reacted with excess hot concentrated sulfuric acid?

A 1

B 2

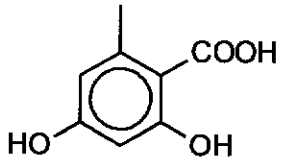
C 3

D 4

25 Compounds **X**, **Y** and **Z** all react with 2,4–dinitrophenylhydrazine but only two of them will cause a reduction in the oxidation number of the metal present in the Tollens' reagent.
Which combination is **X**, **Y** and **Z**?

	X	Y	Z
A	CH_3CONH_2	C_6H_5CHO	CH_3COCH_3
B	CH_3CH_2CHO	$C_6H_5CH_2CHO$	$CH_3CH_2COOCH_3$
C	CH_3CH_2CHO	C_6H_5CHO	CH_3COCH_3
D	CH_3CH_2CHO	$C_6H_5CH_2CHO$	CH_3CHO

26 Orsellinic acid is found in some species of fungus.



orsellinic acid

0.1 mol of orsellinic acid is reacted with excess $Na_2CO_3(aq)$ and the gaseous product formed is passed through a bottle of excess concentrated NaOH.

What is the increase in mass in the bottle of concentrated NaOH?

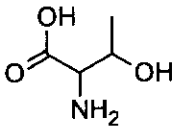
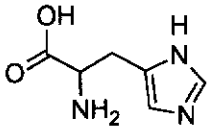
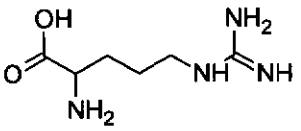
A 1.1 g

B 2.2 g

C 4.4 g

D 6.6 g

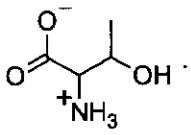
27 A tripeptide, thr-his-arg, is analysed using electrophoresis. The tripeptide is hydrolysed and the resulting solution is then placed at the centre of the plate in a buffer solution of pH 7.0. A potential difference is then applied across the plate. Isoelectric point refers to the pH at which an amino acid is electrically neutral.

amino acid	 threonine	 histidine	 arginine
isoelectric point	5.60	7.59	10.76

Which statements are correct?

1 Arginine is a more basic amino acid than threonine.

2 Histidine will migrate towards the anode while arginine will migrate towards the cathode.

3 The predominant species of threonine at pH 7.0 is  .

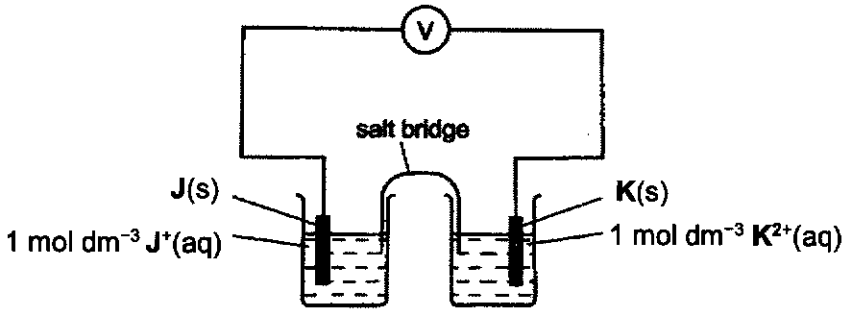
A 1, 2 and 3 **B** 1 and 2 only

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

28 The standard electrode potentials for metals **J** and **K** are given below.

$J^+(aq) \mid J(s) \quad E^\ominus = +0.80\ V$
$K^{2+}(aq) \mid K(s) \quad E^\ominus = -0.44\ V$

The electrochemical cell shown in the diagram below is set up.



Which of the following statements are correct descriptions of this cell?

1 The e.m.f. of the cell is +1.24 V.

2 The anions from the salt bridge will enter the $K^{2+}(aq) \mid K(s)$ half cell.

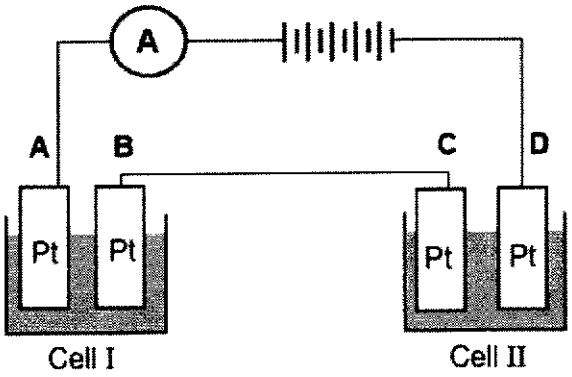
3 The e.m.f. of the cell will decrease when the concentration of K^{2+} ions increases.

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

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

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

A student carried out an experiment involving the electrolysis of aqueous copper(II) sulfate in Cell I and aqueous sulfuric acid in Cell II.



0.00417 mol of copper is deposited at electrode **B** after electrolysis. What is the volume of gas formed at electrode **C** when measured at r.t.p.?

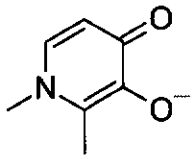
A 0.050 cm^3

B 0.050 dm^3

C 0.10 cm^3

D 0.10 dm^3

30 An electrically neutral, red, octahedral complex **W** is formed when ligand **P** is added to an aqueous solution of Fe^{3+} ions. **W** does not contain water ligands.



P

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

A **P** is a stronger ligand than water.

B **P** acts as a bidentate ligand in **W**.

C The coordination number of **W** is the same as that of $Fe^{3+}(aq)$.

D The oxidation states of iron in **W** and Fe^{3+} are different.

2024 Y6 Preliminary Examination
H2 Chemistry 9729 Paper 1
Suggested Solutions

Answer Key

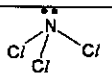
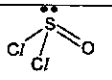
1	2	3	4	5	6	7	8	9	10
B	D	B	D	B	A	D	C	B	A
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
C	C	A	D	A	B	D	D	A	C
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
A	D	C	C	C	B	C	A	B	D

1	B	
	P: $[Ne]3s^23p^3$ No. of unpaired electrons = 3	
×	1	Ti: $[Ar]3d^24s^2$ Ti^{2+}: $[Ar]3d^2$ No. of unpaired electrons = 2
✓	2	V: $[Ar]3d^34s^2$ V^{2+}: $[Ar]3d^3$ No. of unpaired electrons = 3
✓	3	Cr: $[Ar]3d^54s^1$ Cr^{3+}: $[Ar]3d^3$ No. of unpaired electrons = 3

2	D
	ΔH_1 = 2nd IE of Si = +1580 kJ mol^{-1} ΔH_2 = 2nd IE of Al = +1820 kJ mol^{-1} ΔH_3 = sum of 1st & 2nd IE of Si = 786 + 1580 = +2366 kJ mol^{-1} order of decreasing enthalpy change: $\Delta H_3 > \Delta H_2 > \Delta H_1$

3	B
	$2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O$ $CS_2 + 3O_2 \rightarrow CO_2 + 2SO_2$ Hence, SO_2 : CO_2 will be 4 : 1. ⇒ Options A & C are incorrect. Both CO_2 and CS_2 are linear around the central C atom so both are non-polar molecules. CS_2 has a larger, more polarisable electron cloud than CO_2 so CS_2 has stronger instantaneous dipole-induced dipole interactions between molecules. The more significant intermolecular forces result in greater deviation of CS_2 from ideal behaviour.

4	D	
×	A	magnitude of lattice energy $\propto \left\|\frac{q_+ \times q_-}{r_+ + r_-}\right\|$ This is a true statement (Ca^{2+}; 0.099 nm, Na^+; 0.095 nm). but a larger cationic radius leads to a less exothermic lattice energy so this does not explain the higher melting point of CaO.
×	B	This is a true statement as Ca^{2+} has a higher charge than Na^+ but their ionic radii are similar (Ca^{2+}; 0.099 nm, Na^+; 0.095 nm). However, magnitude of lattice energy $\propto \left\|\frac{q_+ \times q_-}{r_+ + r_-}\right\|$ so charge density $\propto \frac{q}{r}$ of the cation alone is not representative of the lattice energy of the compound.
×	C	This is a true statement: sum of ionic radii: CaO: 0.099 + 0.140 = 0.239 nm; NaF: 0.095 + 0.136 = 0.231 nm However, a larger sum of ionic radii leads to a less exothermic lattice energy so this does not explain the higher melting point of CaO.
✓	D	This is a true statement and the magnitude of lattice energy is larger when the magnitude of ionic charges are larger.

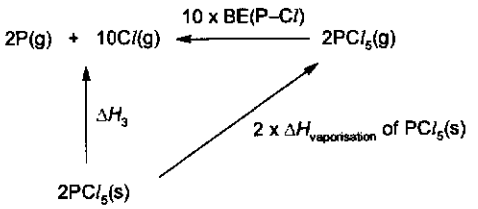
5	B			
	molecule	structure	shape	polarity
	NCl_3		trigonal pyramidal	polar
	HCN	H–C≡N	linear	polar
	$BeCl_2$	Cl–Be–Cl	linear	non-polar
	$SOCl_2$		trigonal pyramidal	polar

Hence, NCl_3 and $SOCl_2$ are polar and have the same shape.

6	A
	Solid **X** is Na_2O which is soluble in water to form the colourless solution of NaOH(aq). On adding $CuSO_4$(s) to NaOH(aq), pale blue ppt of $Cu(OH)_2$ is formed. Na_2O(s) is also soluble in NaOH(aq) as it readily dissolves in water. Solid **Y** is insoluble in water and could be either Al_2O_3(s) or SiO_2(s). Since **Y** is soluble in dilute NaOH(aq), **Y** is Al_2O_3(s) which is amphoteric. Solid **X** (Na_2O) is soluble in HCl(aq) as it readily dissolves in water. Solid **Y** (Al_2O_3) undergoes acid-base reaction with HCl(aq) to form a colourless solution: $Al_2O_3(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2O(l)$

7		D
×	**A**	As ionic radius increases down the group, charge density and hence polarising power of the cation decreases.
×	**B**	The reducing (not oxidising) power of the elements increases.
×	**C**	As polarising power of the cation decreases, the electron cloud of the chloride anion is polarised to a smaller extent so covalent character of the metal chlorides decreases.
✓	**D**	As polarising power of the cation decreases, the electron cloud of the carbonate anion is polarised to a smaller extent and the covalent bonds in the carbonate anion are weakened to a smaller extent. More energy is required to decompose the metal carbonate so thermal stability of the metal carbonates increases.

8	C
	Cl_2 is a stronger oxidising agent than Br_2 so Cl_2 will oxidise Br^- to Br_2 while itself is reduced to Cl^-. $Cl_2(aq) + 2Br^-(aq) \rightarrow Br_2(aq) + 2Cl^-(aq)$ The colourless KBr solution turns orange due to the mixture of orange Br_2(aq) formed and remaining pale yellow Cl_2(aq) so options A & D are incorrect. On addition of $AgNO_3$(aq), white ppt of AgCl is formed. There is no remaining Br^-(aq) ions to form cream ppt of AgBr. $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$

9		B
✓	**1**	$\Delta H_2 = 5 \times BE(Cl-Cl) = 5 \times 244 = +1220$ kJ mol^{-1} $\Delta H_1 = 2 \times \Delta H^{\ominus}_{atomisation}$ of P(s) so $\Delta H_1 > 0$ since atomisation is an endothermic process. Hence $\Delta H_1 + \Delta H_2 > +1220$ kJ mol^{-1}
×	**2**	Note: Reactants and products are in gaseous state when bond energy is used. $\Delta H_3 \neq 10 \times$ P–Cl bond energy $\Delta H_3 = (2 \times \Delta H_{vaporisation}$ of PCl_5(s)) + (10 × P–Cl bond energy) 
✓	**3**	2 mol of PCl_5(s) are formed from the constituent elements in their standard states.

10	A
	$\Delta S < 0$ due to a decrease in number of moles of gas (4 mol to 2 mol). Hence $-T\Delta S > 0$ Since $\Delta H < 0$ and $\Delta G = \Delta H - T\Delta S$, $\Delta G < 0$ when $\lvert -T\Delta S \rvert < \lvert \Delta H \rvert$ Hence the reaction is spontaneous only at low temperature.

11	C
	Let the unknown iodine oxide be I_xO_y. Given, I_xO_y : I^- : I_2 0.02 : 0.2 : 0.12 1 : 10 : 6 In order to balance the number of I atoms, x = 2 Iodine in I_2O_y is reduced to I_2. Iodide is oxidised to I_2. Since [O]: $2I^- \rightarrow I_2 + 2e^-$ Hence, number of mol. of electrons lost by 10 mol. of KI = 10 mol = number of mol. of electrons gained by 1 mol. of I_2O_y So, mol ratio of I_2O_y : e^- gained = 1:10 ∴mol ratio of *each* I in I_2O_y : e^- gained = 1:5 ∴ the oxidation state of each I in I_2O_y is +5 to produce I_2.

12	C
	$p_x \propto [Cl_2]$ Since it is given that the reaction is zero order w.r.t. Cl_2, the rate of reaction should remain unchanged when there is a change to $[Cl_2]$. The **gradient** of p_x vs time graph is indicative of the rate of reaction. Hence, **the gradient** of p_x vs time graph should remain **constant** even when p_x decreases with time due to reaction (downward sloping straight line).

13	A	
✓	1	Colorimetry can be used to measure how the light absorbance of the reaction solution changes at regular intervals as the reaction takes place. The light absorbance is proportional to the colour intensity which is in turn proportional to the concentration of the coloured substance. The rate of reaction is directly proportional to the rate of decrease (or increase) in colour intensity of the reactant (or product).
✓	2	*Concept*: All total volumes were kept constant for all experiments, hence [reactant] $\propto V_{reactant}$. Comparing Expts 1 & 4, when volumes of **B** and **Y** were kept constant, while volume of the coloured solution **A** was doubled, time taken was doubled. ⇨ rate of decolourisation remained constant. ∴Order of reaction w.r.t. **A** is 0. Comparing Expts 1 & 2, when volumes of **A** and **Y** were kept constant, while volume of **B** was doubled, time taken was halved ⇨ rate has doubled. ∴Order of reaction w.r.t. **B** is 1. Comparing Expts 1 & 3, when volumes of **A** and **B** were kept constant, while volume of **Y** was doubled, time taken was halved ⇨ rate has doubled. ∴Order of reaction w.r.t. **Y** is 1. So, rate equation is: rate = k[**B**][**Y**].
✓	3	From option 2, order of reaction w.r.t. **A** is 0. Comparing Expts 4 & 5, since volumes of **B** and **Y** were kept constant, while volume of **A** was halved, time taken should also be halved since rate of decolourisation should remain constant. Hence, the time taken for Expt 5 is 5 s.

14	D
	Concept: Adding inert gas at **constant volume** results in **an increase** in total pressure (due to **increase** in amount of gaseous particles at a constant volume) ⇨ this accounts for the spike observed at **X** as well as the increase in total pressure after **X** for graph **D**. However, partial pressure of each gaseous component **remains unchanged**. Hence, the position of equilibrium **does not shift,** no effect on rate of forward and backward reaction ⇨ this accounts for the second part of graph **D**, after **X**.

15	A	
		Given that: $M(OH)_2(s) + aq \rightleftharpoons M^{2+}(aq) + 2OH^-(aq) \quad \Delta H > 0$ When temperature increases, since forward reaction is endothermic, position of equilibrium (POE) will shift to the **right** to absorb the increase in heat.
✓	1	This statement is correct because an increase in temperature will result in a faster rate of reaction for both directions.
✓	2	Since POE shifts right, there will be a greater amount of OH^- ions, hence pH should increase with the increase in basicity.
✓	3	The value of K_{sp} changes when temperature changes. Since POE shifts right, K_{sp} increases.

16	B	
		Concept: At maximum buffer capacity ⇨ for an acidic buffer, [conjugate base] = [acid] and pH = pK_a ⇨ for a basic buffer, [conjugate acid] = [base] and pOH = pK_b
✗	A	This pair forms a basic buffer. pOH = pK_b ⇨∴pOH = $-\lg(1.78 \times 10^{-5}) = 4.74$ pH = 14 – 4.74 = 9.26
✓	B	This pair forms an acidic buffer, so need to find K_a. $K_a \times K_b = K_w$ $K_a = 10^{-14} \div (2.38 \times 10^{-6})$ $= 4.202 \times 10^{-7}$ mol dm^{-3} ∴pH = pK_a ⇨pH = $-\lg(4.202 \times 10^{-7})$ = 6.38
✗	C	This pair forms an acidic buffer, so need to find K_a. $K_a = 10^{-14} \div (1.33 \times 10^{-12})$ $= 0.007519$ mol dm^{-3} ∴pH = pK_a ⇨pH = -lg 0.007519 = 2.12
✗	D	This pair forms an acidic buffer, so need to find K_a. $K_a = 10^{-14} \div (5.71 \times 10^{-12})$ $= 0.001751$ mol dm^{-3} ∴pH = pK_a ⇨pH = -lg 0.001751 = 2.76

17 **D**

Concept: determine the respective [Ag^+] required to ppt each salt

K_{sp} (Ag_2CrO_4) = $[Ag^+]^2[CrO_4^{2-}]$
= 1.20×10^{-12} mol^3 dm^{-9}

K_{sp} ($AgCl$) = $[Ag^+][Cl^-]$
= 1.80×10^{-10} mol^2 dm^{-6}

For Ag_2CrO_4:

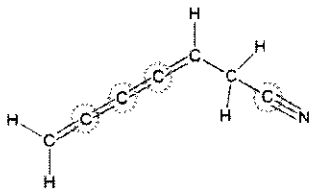
Minimum $[Ag^+] = \sqrt{(1.20\times10^{-12}) \div 0.20}$
= 2.45×10^{-6} mol dm^{-3}

For $AgCl$:
Minimum $[Ag^+] = (1.80 \times 10^{-10}) \div 0.010$
= **1.80×10^{-8} mol dm^{-3}**

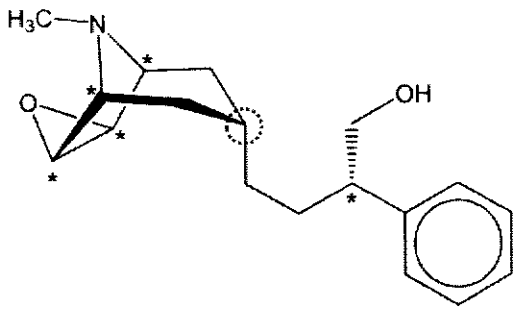
Since minimum [Ag^+] to ppt $AgCl$, < [Ag^+] to ppt Ag_2CrO_4, **$AgCl$ will be ppt out first**.

18 **D**

Solving tip: a sp-hybridised carbon atom is bound to two other atoms via two double bonds or one single and one triple bond.

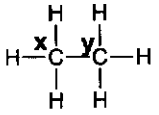


19 **A**



The chiral carbons are marked *.
The circled carbon is achiral as it is bonded to two identical groups (there is an internal plane of symmetry in the ring structure on the left).

20 **C**



There are two carbons in ethane, labelled **x** and **y**.

n =	substitution occurs at	no. of chloroethanes
1	**x**	1
2	**xx,xy**	2
3	**xxx, xxy**	2
4	**xxxy, xxyy**	2
5	**xxxyy**	1
6	**xxxyyy**	1

21 A
Quick solving tip: the first step must involve an addition reaction since the second step is a strong oxidation reaction. The reagent that is suitable incorporates only one -OH group.

✓	**A**	As discussed in quick solving tip.
×	**B**	Since the reagent used is HBr(g), there is no possibility of incorporating a -OH group.
×	**C**	H, being a diol, will yield diketo instead of target compound.
×	**D**	There is no possibility of incorporating a keto group in one step from an alkene.

22 **D**

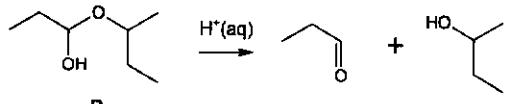
×	**1**	Both benzene and cyclohexene can react with hydrogen under these drastic conditions, it does not serve as a good distinguishing test as there is no clear colour change.
✓	**2**	Oxidative cleavage of cyclohexene will occur with decolourisation of purple potassium manganate(VII) observed.
✓	**3**	Cyclohexene will decolourise orange aqueous bromine solution but not benzene.

23 **C**
The bond length of C-F bond is shorter than that of C-Cl bond and it should be a stronger bond. Hence, it is less likely to break to produce fluorine radicals. Options B and D are incorrect.

Option A is incorrect. Fluoroalkanes are more volatile as it has a lower boiling point than chlorofluoroalkanes. The electron cloud size of fluoroalkanes is smaller and less polarisable. Hence, the instantaneous dipole-induced dipole interaction is weaker between fluoroalkanes and therefore require lower amount of energy to overcome the interactions. However, the volatility is not a cause of ozone depletion.

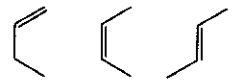
24 **C**

Quick solving tip: Note that the left hand side of R bears a three-carbon long chain and that right hand side of R carry a four-carbon chain. This indicates that the hydrolysis happens at the ether oxygen. Using the molecular formula of T, one can deduce that it is a saturated alcohol.



R ($C_7H_{16}O_2$) **S** (C_3H_6O) **T** ($C_4H_{10}O$)

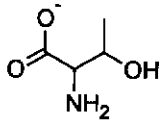
T undergoes elimination of water (dehydration) to form three different alkenes.



25	**C** Since all compounds react with 2,4-dinitrophenylhydrazine, all compounds contain carbonyl groups.	
×	**A**	Compound **X** is not a carbonyl group but an amide.
×	**B**	Compound **Z** is not a carbonyl group but an ester.
✓	**C**	All compounds contain carbonyl group and compound **Z** will not reduce Ag^+ in Tollens' reagent as it is a ketone.
×	**D**	All compounds are aldehydes which will cause a reduction of Ag^+ in Tollens' reagent.

26 **B**

Only the -COOH group is acidic enough to react with Na_2CO_3(aq) but not the other two phenol groups. Since $2H^+ \equiv CO_3^{2-} \equiv CO_2$, $H^+ \equiv 0.5CO_2$. Hence, no. of mol of CO_2 produced = 0.1 × 0.5 = 0.05. This is equivalent to mass increase of 44 × 0.05 = 2.2 g.

27	**C**	
✓	**1**	Arginine has a higher pI than threonine because the side chain of arginine is more basic than the side chain of threonine resulting in higher pH required for arginine to form a zwitterion.
×	**2**	At pH = 7, both histidine and arginine carry overall +1 charge as both the amino and side chain remains protonated (pH < pI). Hence, both should migrate to the negatively charged cathode.
×	**3**	At pH = 7, a larger proportion of threonine exists as single negatively charged as the amino-NH_3^+ group gets progressively deprotonated (because pH > pI). Hence, the predominant species is  .

28	**A** Since the reduction potential of J^+ is more positive than K^{2+}, J^+ is reduced to J while K is oxidised to K^{2+}.	
✓	**1**	$E_{cell}^{\ominus}$ = (+0.80) – (–0.44) = +1.24 V
✓	**2**	Anions from salt bridge will flow in to counter-balance the formation of K^{2+}.
✓	**3**	By LCP, when the concentration of K^{2+} increases, the position of equilibrium will shift to reduce K^{2+} to decrease the concentration of K^{2+}. This will make the reduction potential of K^{2+} more positive and hence, the emf will decrease.

29 **B**

Electrode A is positively charged, B is negatively charged, C is positively charged and D is negatively charged. Cu^{2+} is reduced at electrode B while H_2O is preferentially oxidised at electrode C.

$$S_2O_8^{2-} + 2e^- \rightleftharpoons 2SO_4^{2-} \qquad E^{\ominus} = +2.01\ V$$

$$O_2 + 4H^+ + 4e^- \rightleftharpoons 2H_2O \qquad E^{\ominus} = +1.23\ V$$

Since 0.00417 mol of copper is deposited, 0.00834 mol of e^- is required to do so. This same amount of e^- also flowed through to electrode C. Since $O_2 \equiv 4\ e^-$, (0.00834/4) $e^- \equiv 0.002085\ O_2$. Therefore, the volume of O_2 produced at C is 0.002085 × 24 = 0.050 dm^3.

30	**D**	
correct	**A**	P, being a stronger ligand, will displace H_2O as ligand and this causes yellow $[Fe(H_2O)_6]^{3+}$ ions to form a red complex.
correct	**B**	Since **W** is electrically neutral and octahedral, **W** must be $[Fe(P)_3]$. To have a coordination number six, **P** must be bidentate.
correct	**C**	
incorrect	**D**	There is no change in oxidation state when a ligand coordinates to a metal ion centre.