1 A sample of boron contains two naturally occurring isotopes, ^{10}B and ^{11}B. This sample has a relative atomic mass value of 10.75.

What is the percentage of the isotope ^{11}B in the sample?

A 20 **B** 25 **C** 75 **D** 80

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

On losing an electron, which particle would have the greatest number of unpaired electrons?

A C^-

B Fe^{3+}

C Ti^{2+}

D P

3 Particle **X** has a charge of +1 and a proton number, n.

Particle **Y** has a proton number of (n+1) and is isoelectronic with **X**.

Which of the following statements correctly describes **X** and **Y**?

A **X** and **Y** are isotopes.

B The atoms of **X** and **Y** have the same electronic configurations.

C **Y** has a charge of +1 and same charge density as that of **X**.

D **Y** has a charge of +2 and smaller ionic radius than **X**.

4 The Valence Shell Electron Pair Repulsion (VSEPR) Theory is used to predict the shapes of molecules or polyatomic ions.

Which of the following pairs of species are planar?

A F_2O and PF_5

B SO_3^{2-} and ClF_3

C BrF_4^- and NO_2

D ICl_5 and CO_2

5 Which of these phenomena **cannot** be explained by hydrogen bonding?

1 NH_4Br has a higher boiling point than HBr.

2 Ice is less dense than water.

3 Dimerisation of NO_2 to form N_2O_4.

4 Ethanoic acid forms dimers which dissolved in organic solvents

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

6 A 2.50 dm^3 vessel containing ethane gas at a pressure of 1.50 x 10^5 Pa is connected to a 7.50 dm^3 vessel containing methane gas at a pressure of 2.50 x 10^5 Pa. The gases are allowed to mix freely. The temperature of the system is then raised from 100 °C to 350 °C. *(Note that there is no chemical reaction between both gases)*

What is the final pressure of the system?

A 2.25 x 10^5 Pa

B 3.76 x 10^5 Pa

C 6.68 x 10^5 Pa

D 7.88 x 10^5 Pa

7 Which statements concerning only the elements in the third period, sodium to argon, are correct?

1 The element with the highest pH for its chloride in water is sodium.

2 The element with the highest electrical conductivity is aluminium.

3 The element with the highest melting point for its oxide is silicon.

4 The element that has eight atoms in its molecule is sulfur.

A 1 and 4 only

B 2 and 3 only

C 1, 2 and 4 only

D 1, 3 and 4 only

8 The equations for three reactions are given below:

$$Cl_2(g) + H_2S(g) \rightarrow 2HCl(g) + S(s)$$

$$SO_2(g) + 2H_2S(g) \rightarrow 2H_2O(l) + 3S(s)$$

$$Cl_2(g) + 2H_2O(l) + SO_2(g) \rightarrow 2HCl(aq) + H_2SO_4(aq)$$

Which is the correct order of strength of the three reacting gases as oxidising agents?

	Strongest	⟶	**Weakest**
A	Cl_2	SO_2	H_2S
B	Cl_2	H_2S	SO_2
C	H_2S	SO_2	Cl_2
D	SO_2	H_2S	Cl_2

[Turn over

9 The equation for the reaction of nitrogen monoxide with oxygen is shown below.

$$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$$

From initial rate experiments, the following rate equation was derived.

$$\text{rate} = k[NO]^2[O_2]$$

The results of the initial rates experiments are shown.

initial [NO] / mol dm^{-3}	initial [O_2] / mol dm^{-3}	initial rate of formation of NO_2/ mol dm^{-3} s^{-1}
0.0010	0.002	7.00×10^{-6}
0.0020	0.003	**a**
b	0.004	1.26×10^{-4}

What are the missing values **a** and **b**?

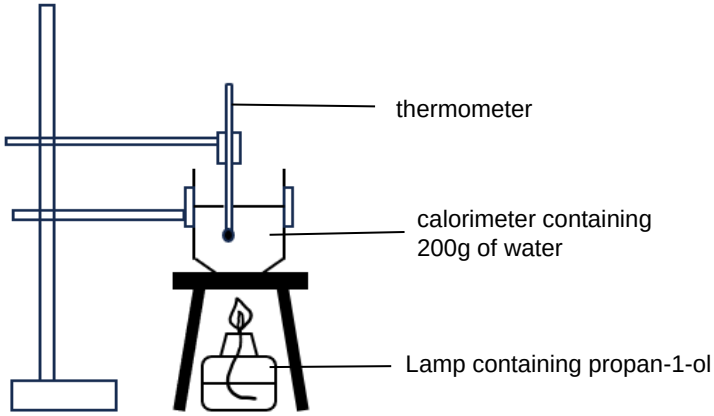
	a	**b**
A	1.9×10^{-5}	0.0030
B	1.9×10^{-5}	0.0045
C	4.2×10^{-5}	0.0030
D	4.2×10^{-5}	0.0045

10 Caffeine is a drug that increases the activity of the brain and nervous system. Its elimination from the body follows a first-order kinetics with a half-life of 5.0 h.

How long will it take for someone who took 50 mg of caffeine, to have 10 mg of caffeine left in his system?

A 5.0 h **B** 11.6 h **C** 25.0 h **D** 58.0 h

11 A student carried out an experiment shown below to determine the enthalpy change of combustion of propan-1-ol (M_r = 60.0). It was found that the combustion of 1.0 g of propan-1-ol raises the temperature of 200 g of water by 40 °C.



Given that the enthalpy change of combustion of propan-1-ol is –2200 kJ mol^{-1}, what is the efficiency of the heat transfer process? Assuming the specific heat capacity of water is 4.18 J g^{-1} K^{-1}.

A 88.5 %

B 91.2 %

C 95.2 %

D 99.5 %

12 For the reaction, $3C(s) + Cr_2O_3(s) \longrightarrow 2Cr(s) + 3CO(g)$ $\Delta H^{\ominus} = +1120$ kJ mol^{-1}

Which statement is correct?

A The reaction is spontaneous at all temperatures.

B The reaction is not spontaneous at any temperature.

C The reaction is spontaneous only at low temperature.

D The reaction is spontaneous only at high temperature.

[Turn over

13 Gaseous methanol undergoes the following reaction as shown below.

$$CH_3OH(g) \rightleftharpoons CO(g) + 2H_2(g) \qquad K_c = 5.0 \text{ mol}^2 \text{ dm}^{-6}$$

Determine the initial concentration of CH_3OH such that the equilibrium concentration of CH_3OH would be 2.0 mol dm^{-3}.

A 3.36

B 4.35

C 4.68

D 5.25

14 Ammonia is commonly used as fertiliser. In an experiment, 0.100 mol dm^{-3} of ammonia dissociates partially in the presence of water according to the equation below.

$$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

Which of the following statements is correct?

A K_b of ammonia increases upon dilution.

B pH remains unchanged upon dilution.

C Ammonia acts as a Lewis base.

D The degree of dissociation of ammonia remains unchanged upon dilution.

15 The numerical value of the solubility product of magnesium phosphate, $Mg_3(PO_4)_2$, is 1.0×10^{-24}. What is the solubility of $Mg_3(PO_4)_2$?

A 1.00×10^{-12} mol dm^{-3}

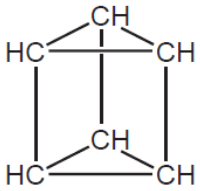
B 6.21×10^{-6} mol dm^{-3}

C 1.11×10^{-5} mol dm^{-3}

D 1.86×10^{-5} mol dm^{-3}

16 *Prismane* is an isomer of benzene which has a molecular formula of C_6H_6, in which one hydrogen atom is attached to each carbon atom. *Prismane* is far less stable than benzene.

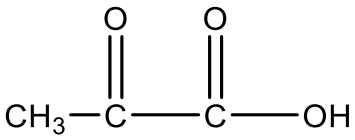
How many di-brominated products, excluding stereoisomers, can *Prismane* form via free radical substitution?



A 2 **B** 3 **C** 4 **D** 5

[Turn over

17 Compound **J** reacts with HCN under suitable conditions to form compound **K**.

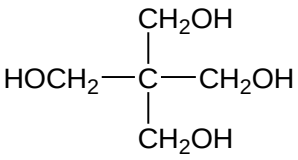


Compound **J**

What is the number of σ and π bonds in compound **K**?

	σ	π
A	9	2
B	12	3
C	13	3
D	14	4

18 Pentaerythritol is used as an intermediate in the manufacture of paint.



pentaerythritol

Which statement about pentaerythritol is correct?

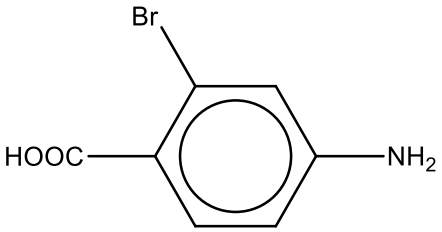
A It can react with HBr(aq) via nucleophilic substitution.

B Its empirical and molecular formulae are different.

C It can undergo elimination with hot concentrated sulfuric acid to form an alkene.

D One mole of pentaerythritol gives two moles of hydrogen gas on reaction with excess sodium.

19 Compound **F** may be synthesised from methylbenzene.



Compound **F**

Which of the following synthetic routes will most likely yield compound **F**?

A nitration → bromination → oxidation → reduction

B bromination → oxidation → nitration → reduction

C bromination → nitration → oxidation → reduction

D nitration → reduction → bromination → oxidation

20 Which of the following could explain why benzene does not undergo electrophilic addition reaction?

1 Delocalised pi electrons stabilise the structure.

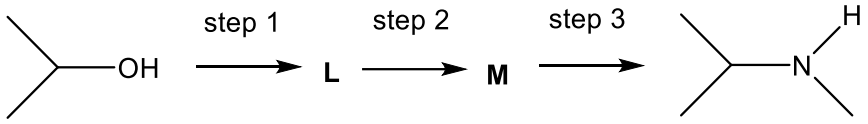
2 Benzene is unable to act as a nucleophile.

3 All carbon atoms in benzene are sp^2 hybridised.

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

[Turn over

21 The following is a series of reactions involving propan–2–ol.



Which of the following give the correct reagents and conditions for steps 1, 2 and 3?

	step 1	step 2	step 3
A	alcoholic KCN, heat	$H_2(g)$, Pt, high heat and pressure	excess $CH_3Br(g)$
B	HBr(g)	conc alcoholic NH_3, heat in sealed tube	excess $CH_3Br(g)$
C	HBr(g)	alcoholic KCN, heat	$H_2(g)$, Pt, high heat and pressure
D	acidified $K_2Cr_2O_7$, heat	HCN, trace NaOH (aq), cold	$H_2(g)$, Pt, high heat and pressure

22 Compounds **P** and **Q** have the following formulae:

$CHOCH(OH)COCH_3$ **P**

$CH_2(OH)CH_2OCOCH_3$ **Q**

Which of the following statements apply to these compounds?

1 Both react with 2,4–dinitrophenylhydrazine.

2 Both react with aqueous alkaline iodine.

3 **P** reacts with Tollen's reagent but **Q** does not.

A 1, 2 and 3 are correct.

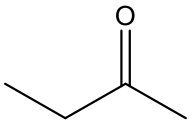
B 1 and 2 only are correct.

C 2 and 3 only are correct.

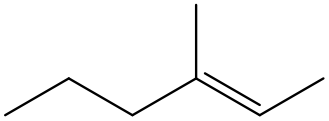
D 3 only is correct.

23 Which reaction will **not** produce a mixture of two enantiomers?

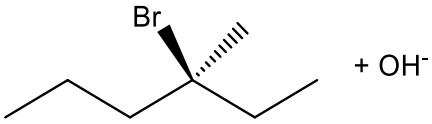
A



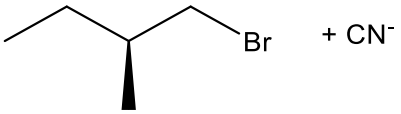
B



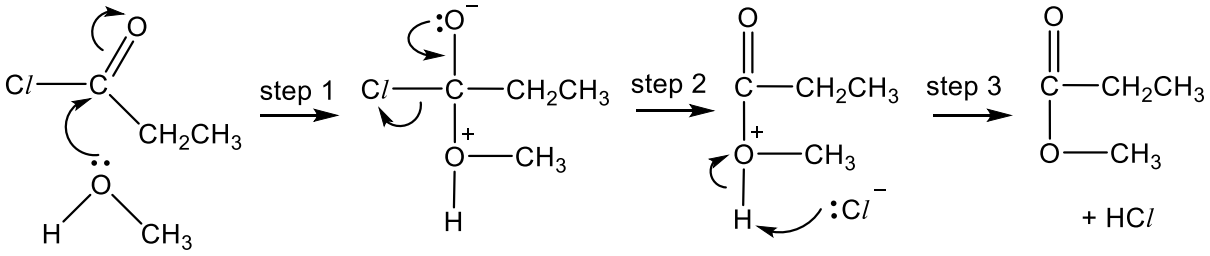
C



D



24 The reaction sequence given shows a possible mechanism for the reaction between methanol and propanoyl chloride.

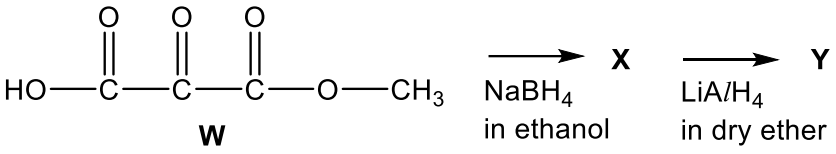


What are the types of reaction occurring in step 1 and 2?

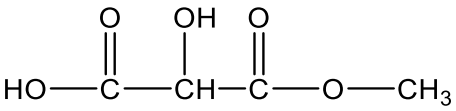
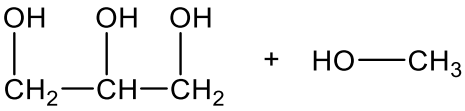
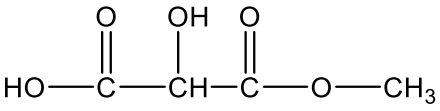
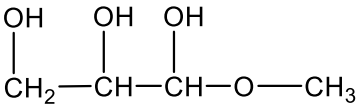
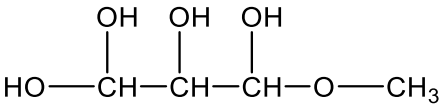
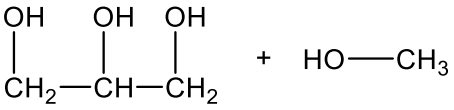
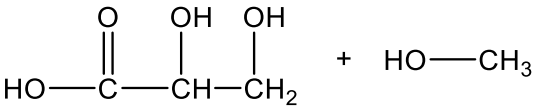
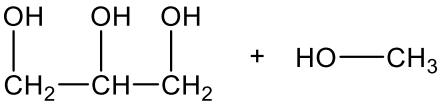
	step 1	step 2
A	electrophilic addition	elimination
B	electrophilic addition	hydrolysis
C	nucleophilic addition	elimination
D	nucleophilic addition	hydrolysis

[Turn over

25 The compound **W** shown below undergoes the two reactions as follows:



What could be compounds **X** and **Y**?

	X	**Y**
A		
B		
C		
D		

26 Nitrobenzene reacts with tin in concentrated hydrochloric acid followed by aqueous sodium hydroxide to form phenylamine.

Which of the following statements is correct for the above reaction?

A Tin is used as a catalyst in this reaction.

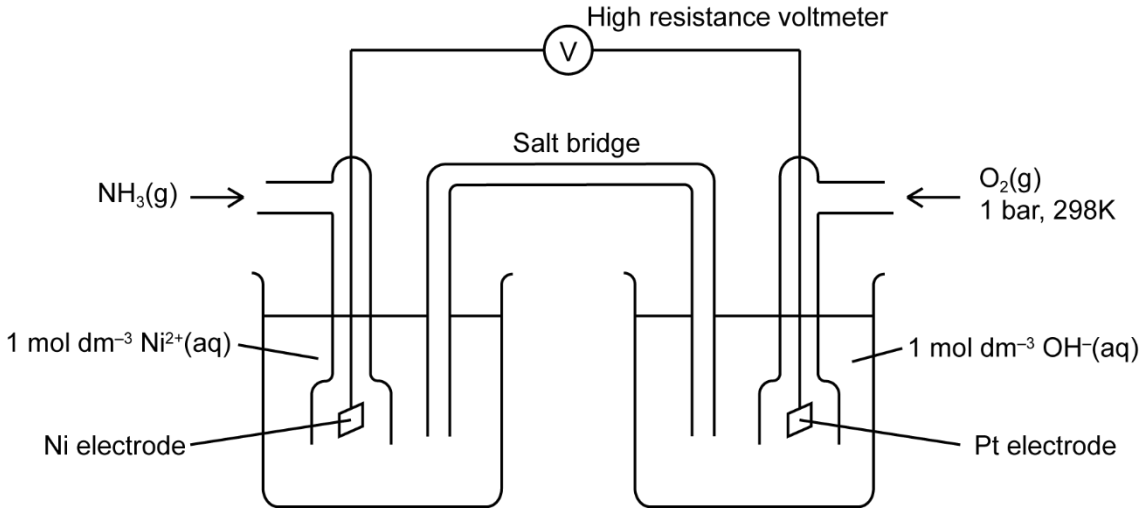
B The oxidation number of the oxygen atom decreased in this reaction.

C $LiAlH_4$ is a suitable alternative to carry out this conversion.

D NaOH is required to form phenylamine from phenylammonium chloride.

27 *Use of Data Booklet is relevant to this question.*

An electrochemical experiment was set up, with ammonia gas passing through the left electrolyte until it reached saturation.



Using the given information and relevant data from the Data Booklet, determine the resultant cell potential.

A +0.65 V **B** +0.91 V **C** +1.48 V **D** +1.74 V

28 An aqueous solution of copper(II) nitrate is electrolysed for 25 min with a constant current of 3.0 A. What is the expected gain in mass of the cathode?

A 0.025 g **B** 0.68 g **C** 1.5 g **D** 3.0 g

29 Which statement correctly describes the difference between magnesium metal and titanium metal?

1 For two samples with identical volume, the mass of magnesium is less than the mass of titanium.

2 Magnesium melts at a lower temperature than titanium.

3 Titanium has catalytic properties while magnesium does not.

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

[Turn over

30 Which of the following processes does **not** involve a change in colour of the solution?

A Adding Zn(s) to $V(NO_3)_2$(aq)

B Adding $Na_2S_2O_3$(aq) to I_2(aq)

C Adding concentrated HC*l* to $Cu(NO_3)_2$(aq)

D Adding methanoic acid to acidified $KMnO_4$