Section A

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

1. A solid hydrocarbon was completely combusted in a closed vessel at 120 ^{o}C. The residual gas had a volume of 64 cm^3, which decreased by 24 cm^3 after bubbling through a dehydrating agent. After this, 40% of the final gas volume consisted of oxygen. What is the empirical formula of the hydrocarbon?

A CH
B CH_2
C CH_3
D C_2H_3

2. When cobalt metal is reacted with a solution containing cobalt(III) ions, cobalt(II) ions are formed. How many moles of Co and Co^{3+}(aq) would result in a mixture containing both cobalt(II) and cobalt(III) ions in the mole ratio of 3:1 after the reaction had taken place?

	Moles of Co	Moles of Co^{3+}
A	1	2
B	1	3
C	1	5
D	2	3

3. Which graph does not share the same general shape with the other three graphs according to the ideal gas law for a fixed mass of gas?

A pV against p (at constant T)
B V/T against T (at constant p)
C p against V (at constant T)
D pV against V (at constant T)

4. Which element will possess an empty s orbital after forming a singly-charged cation?

A Barium
B Vanadium
C Copper
D Gallium

5. Which of the following reactions will form a product with the same shape as the reactant with respect to the underlined element?

A $2\underline{Al}Cl_3 \rightarrow \underline{Al_2}Cl_6$
B $2H_2\underline{O_2} \rightarrow 2H_2O + \underline{O_2}$
C $\underline{P}Cl_3 + Cl_2 \rightarrow \underline{P}Cl_5$
D $CH_3CH_2\underline{C}HO + [O] \rightarrow CH_3CH_2\underline{C}OOH$

6. Which of the following is arranged correctly in the order of decreasing melting points?

A Sulfur > Chlorine > Argon
B Carbon dioxide > Silicon dioxide > Germanium dioxide
C Beryllium chloride > Magnesium chloride > Calcium chloride
D Sodium > Magnesium > Aluminium

7. A student dissolved 0.238 mol of sodium fluoride in 300 cm^3 of water.

Given the following data:

Lattice energy of NaF	$-918\ kJ\ mol^{-1}$
Enthalpy change of hydration of F^-	$-457\ kJ\ mol^{-1}$
Enthalpy change of hydration of Na^+	$-390\ kJ\ mol^{-1}$

What would be the initial temperature of the water if the final temperature of the solution is 20.00^oC?

Assume that the specific heat capacity of sodium fluoride solution is $4.18\ J\ g^{-1}\ K^{-1}$.

A 6.52^oC

B 13.48^oC

C 20.00^oC

D 33.48^oC

8. Ammonia gas and hydrogen chloride gas react to form ammonium chloride as shown in the equation below:

$$NH_3(g) + HCl(g) \rightarrow NH_4Cl(s) \qquad \Delta H^{\ominus} = -176\ kJ\ mol^{-1}$$

The standard entropy change of this reaction is $-284\ J\ K^{-1}\ mol^{-1}$.

Which of the following statements is **not** correct?

A At room temperature, $\Delta G^{\ominus} = +84.4\ kJ\ mol^{-1}$.

B The reactants are less stable than the product.

C The reaction is spontaneous at low temperatures and non-spontaneous at high temperatures.

D There is a decrease in the degree of disorderliness.

9. The following experimental results are obtained for a reaction with the general rate equation of:

$$\text{rate} = k\,[\mathbf{M}]^{x}\,[\mathbf{N}]^{y}\,[\mathbf{L}]$$

Experiment	[M] / mol dm^{-3}	[N] / mol dm^{-3}	[L] / mol dm^{-3}	Relative rate
1	0.1	0.2	0.3	1
2	0.2	0.6	1.2	72

Which of the following are possible values of ***x*** and ***y***?

	x	***y***
A	1	1
B	2	1
C	1	2
D	2	2

10. Which of the following will decrease the rate constant for a reaction?

A Decrease in concentration

B Decrease in temperature

C Decrease in pressure

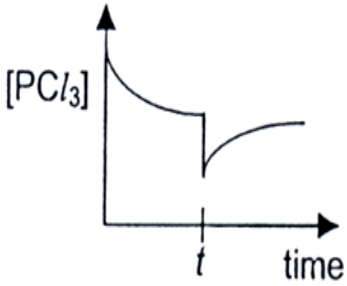
D Addition of catalyst

11. Phosphorus trichloride and chlorine react according to the following equation:

$$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g)$$

A mixture of PCl_3 and Cl_2 was placed in a syringe and brought to equilibrium at time *t* and the following graph was obtained.

Which of the following accounts for the drop in $[PCl_3]$ at time *t*?



A PCl_5 was added to the mixture

B Argon gas was added to the mixture

C The syringe was heated

D The plunger of the syringe was withdrawn until the volume was twice the initial volume

12. Which of the following statements about phosphoric(V) acid is **not** correct?

A HPO_4^{2-} has a higher K_b value than $H_2PO_4^-$.

B PO_4^{3-} can react as a base.

C $H_2PO_4^-$ can react both as an acid and as a base.

D H_3PO_4 has a higher pK_a than HPO_4^{2-}.

13. 95 cm^3 of M^{2+} ions is mixed with an an equal volume of X^- ions at 25°C. Which of the following initial concentrations of M^{2+} and X^- will result in the precipitation of MX_2?
(K_{sp} of $MX_2 = 7.67 \times 10^{-13}$ mol^3 dm^{-9})

	$[M^{2+}] / 10^{-4}$ mol dm^{-3}	$[X^-] / 10^{-4}$ mol dm^{-3}
A	1	1
B	1	2
C	2	1
D	2	2

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

Glucose can be reacted with silver ions to form a silver mirror in the following reaction.

$$C_6H_{12}O_6 + 2Ag^+ + H_2O \rightarrow 2Ag + C_6H_{12}O_7 + 2H^+ \qquad E^{\ominus}_{cell} = +0.75\ V$$

Which of the following metal ions **cannot** be used for a possible reaction with glucose?

A Mn^{3+}

B V^{3+}

C Fe^{3+}

D Co^{3+}

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

The following reaction does not occur under standard conditions.

$$2NO_3^-(aq) + 8H^+(aq) + 6Cl^-(aq) \rightleftharpoons 2NO\ (g) + 4H_2O\ (l) + 3Cl_2\ (g)$$

Which of the following can result in the reaction occuring?

A Decreasing the volume of the reaction vessel

B Addition of nitrogen monoxide

C Decreasing the pH

D Addition of chlorine

16. The properties of the oxides of four Period 3 elements **W, X, Y** and **Z** are given below.

- The oxide of **W** is insoluble in water and in dilute acid but soluble in concentrated sodium hydroxide.
- The oxide of **X** is amphoteric.
- The oxide of **Y** reacts with dilute potassium hydroxide at room temperature.
- The oxide of **Z** dissolves in water to form a solution of pH = 13.

Which of the following is correct in order of increasing atomic number?

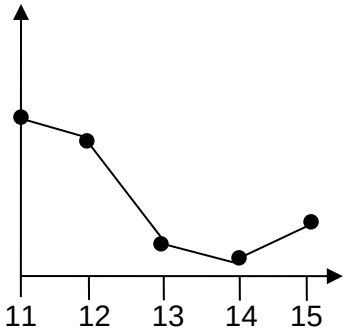
A **Z, X, W, Y**

B **W, X, Y, Z**

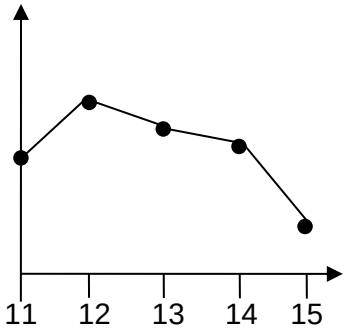
C **Z, W, X, Y**

D **Z, Y, W, X**

17. The following graphs show how two properties of the elements, Na to P, and their compounds, vary with proton number.



Graph 1



Graph 2

What properties are shown by the two graphs?

	Graph 1	**Graph 2**
A	Melting point of oxide	Conductivity of element
B	Melting point of oxide	Melting point of chloride
C	Melting point of chloride	Melting point of oxide
D	Melting point of element	Conductivity of element

18. A student observed the reactions when sodium chloride was added separately to concentrated sulfuric acid and concentrated phosphoric acid. The experiment was repeated using sodium iodide.

Reagent	Observation with sodium chloride	Observation with sodium iodide
conc. H_2SO_4	white fumes evolved	purple vapour evolved
conc. H_3PO_4	white fumes evolved	white fumes evolved

Which deduction can be made from these observations?

A The reducing power of HI is greater than that of HC*l*.

B The bond length of HI is smaller than that of HC*l*.

C Concentrated phosphoric acid is a stronger oxidising agent than concentrated sulfuric acid.

D Basicity of concentrated phosphoric acid is greater than concentrated sulfuric acid.

19. The following data refer to cobalt as a typical transition element and calcium as an s-block element.

Which of the following properties shows the correct data for both elements?

	Property	Cobalt	Calcium
A	Metallic radius / nm	0.150	0.117
B	Electrical conductivity / relative units	10.1	50
C	Melting point / ^oC	1495	1965
D	Density / g cm^{-3}	8.9	1.54

20. Which of the following cannot act as a ligand?

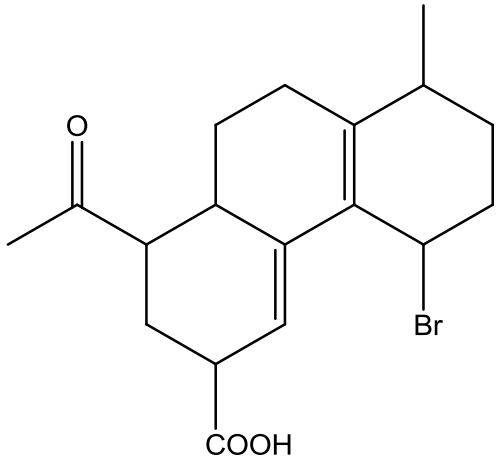
A AlH_4^-

B N_2H_4

C CH_3OH

D CO

21. The following compound is reacted with $LiAlH_4$ in dry ether.



What is the number of stereoisomers the product would possess?

A 2^6

B 2^7

C 2^8

D 2^9

22. Which statement with regards to the reaction of monobromination of benzene is correct?

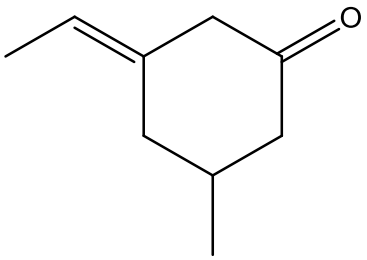
A This is considered a nucleophilic substitution reaction.

B The intermediate consists of 4 pi electrons.

C The intermediate is planar.

D Upon addition of ethanolic silver nitrate solution to bromobenzene, a cream precipitate would be observed.

23. The compound below was reacted with hot alkaline potassium manganate(VII) solution.



Which statement is correct?

A The organic products consist of a total of 2 sp^2 hybridised carbons.

B There are 3 chiral centres in the organic products.

C The organic products would not form a yellow precipitate with warm alkaline iodine solution.

D The organic products would not form an orange precipitate with 2,4–DNPH.

24. In the following synthesis route, which reaction mechanism is **not** used?

$$CH_3CH_2OH \rightarrow CH_2{=}CH_2 \rightarrow CH_2XCH_2X \rightarrow CH_2(NH_2)CH_2NH_2$$

A electrophilic addition

B elimination

C nucleophilic substitution

D reduction

25. A cyclic organic compound has the molecular formula $C_4H_7NO_2$. Which pair of the functional groups can be present in this molecule?

A one ester group and one primary amine group

B one ester group and one nitrile group

C one primary alcohol group and one primary amide group

D one tertiary alcohol group and one tertiary amine group

26. Which statement about ethanoic acid and its derivatives is correct?

A Ethanamide is soluble in water to form a neutral solution due to the formation of equal proportions of ethanoic acid and ammonia.

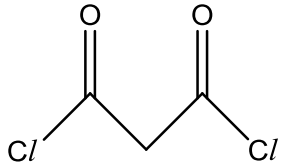
B Ethanoic acid has a relative molecular mass of 120 in liquid hexane.

C Ethanoyl bromide hydrolyses in water to produce reddish brown fumes.

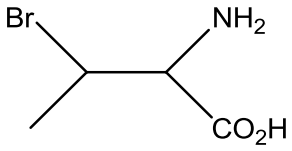
D Ethyl ethanoate, upon reaction with 2,4-DNPH, gives an orange precipitate.

27. Which compound would show the greatest ease of hydrolysis?

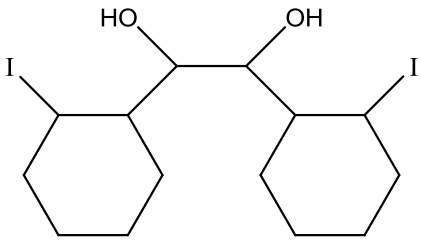
A



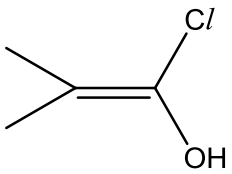
B



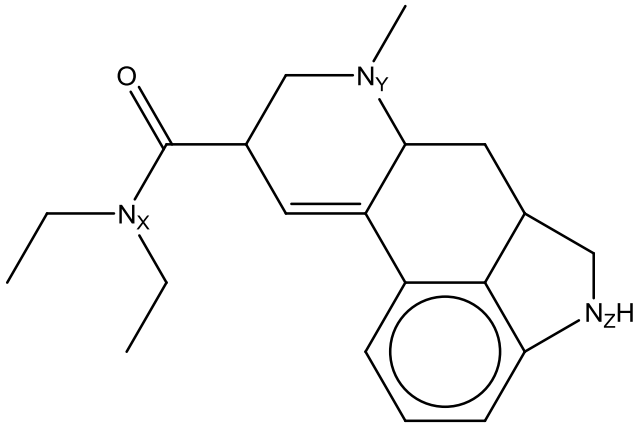
C



D



28.



The compound above has a total of three nitrogen atoms (N_X, N_Y and N_Z). Which sequence show an increase in pOH?

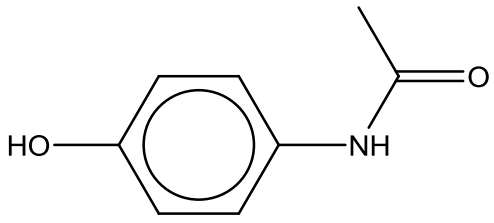
A N_X, N_Y, N_Z

B N_X, N_Z, N_Y

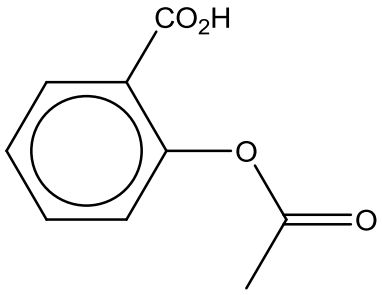
C N_Y, N_X, N_Z

D N_Y, N_Z, N_X

29. Two common drugs administered when a patient experiences headache or fever are paracetamol and aspirin.



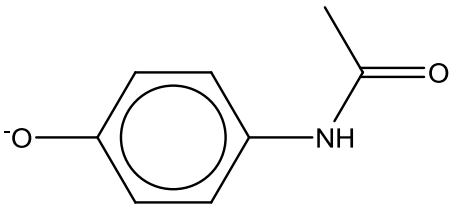
paracetamol



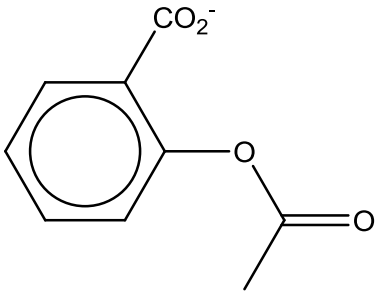
aspirin

A solution of the two drugs was hydrolysed using hot aqueous sodium hydroxide. Which organic product would be produced?

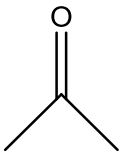
A



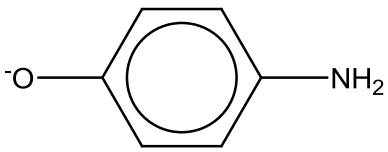
B



C



D



30. Which statement about proteins and amino acids is **not** correct?

A Amino acids exist as crystalline solids at room temperature.

B Hydrogen bonds can be found in secondary and tertiary structures of proteins

C Denaturation of proteins leads to the breaking down of the primary structure.

D Amino acids can act as buffer solutions.

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct. Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).
The responses **A** to **D** should be selected on the basis of

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

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

31. Which of the following are disproportionation reactions?

1 $3Cl_2 + 6NaOH \rightarrow 5NaCl + NaClO_3 + 3H_2O$

2 $IO_3^- + 5I^- + 6H^+ \rightarrow 3I_2 + 3H_2O$

3 $15Se + SeCl_4 + 4AlCl_3 \rightarrow 2Se_8[AlCl_4]_2$

32. Which of the following pairs are both planar and polar?

1 OCl_2 and SO_2

2 XeF_4 and SO_3

3 IF_5 and H_3O^+

33. Which of the following increase with decreasing temperature for the dissociation of water?

Temperature/ ^oC	K_w/ $mol^2\ dm^{-6}$
50	5.5×10^{-14}
25	1.0×10^{-14}

1 pK_b

2 pH

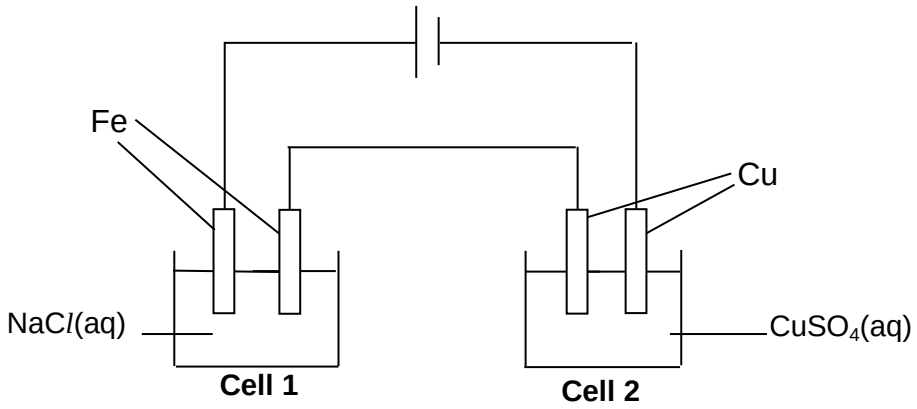
3 pK_w

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

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

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

Which of the following statements can be deduced from the diagram below?



1 Size of the anode in **Cell 1** decreases.

2 Colour of the electrolyte in **Cell 2** remains the same.

3 Effervescence is observed in both cells immediately.

35. 0.5 mol of each of the following was added to 100 cm^3 of water. Which of the following solutions are arranged correctly in the order of increasing pH?

1 $SiCl_4$, $MgCl_2$, NaCl

2 H_2SO_4, HNO_3, CH_3CH_2COOH

3 NH_3, CH_3NH_2, KOH

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

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

36. *Use of the Data Booklet is relevant to this question*.
When iron filings are added to nitric acid, a yellow solution and nitrogen dioxide gas are formed. On the addition of ammonium thiocyanate to the resultant solution, a blood-red colouration due to an iron (III) complex is formed.

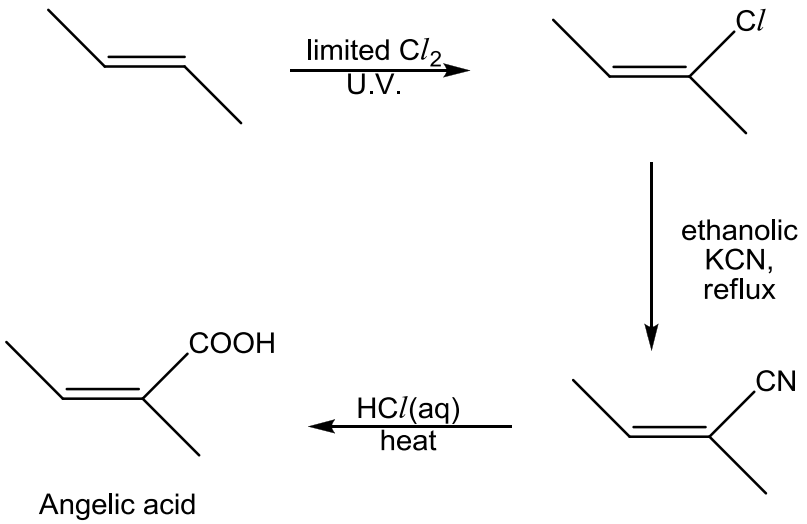
Which statements are correct?

1 The oxidation state of N decreases from +6 to +4 in the first reaction.

2 Redox and ligand exchange have taken place.

3 The standard cell potential of the reaction between iron filings and nitric acid is +0.85 V.

37. The following steps represent a student's attempt to synthesise angelic acid from but-2-ene.



Angelic acid

Unfortunately, he was unable to synthesise angelic acid. Which steps were incorrect?

1 HCl(aq), heat

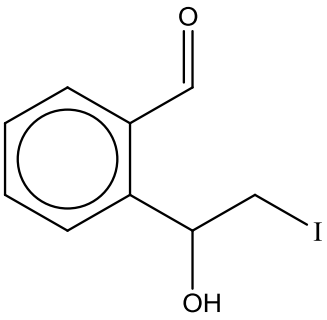
2 limited Cl_2, U.V.

3 Ethanolic KCN, reflux

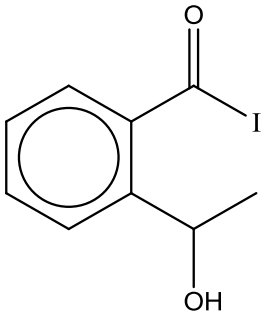
A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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

38.



compound **X**



compound **Y**

Which of the following reagents would react with both compounds above?

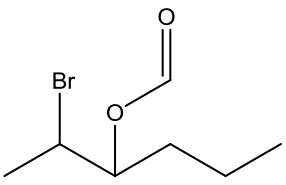
1 warm alkaline iodine solution

2 warm Fehling's solution

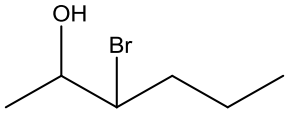
3 2,4–DNPH

39. Hydrogen iodide reacts with liquid hex-2-ene to form 2-iodohexane and 3-iodohexane. When hex-2-ene is mixed with bromine monochloride, Br*Cl*, dissolved in aqueous sodium methanoate, a similar reaction occurs. Which are the possible products in the mixture?

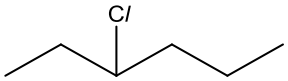
1



2



3



40. Deuterium, D, is the $^{2}_{1}\mathrm{H}$ isotope of hydrogen. Which reactions could give an organic compound having a chiral centre?

1 $CH_3CHO \xrightarrow{DCN,\ NaOH}$

2 $C(CH_3)_2{=}CH_2 \xrightarrow{DCl}$

3 $CH_3COCH_3 \xrightarrow{NaBD_4,\ CD_3OD}$

~~~ END ~~~