- 1 Which species deflects the most in an electric field?
 - A ⁷Li⁺
 - **B** ²⁴Mg²⁺
 - **C** ³²S²⁻
 - **D** ²⁷A*l*³⁺
- 2 The shape of each p-orbital is represented as two lobes.

How many 3d orbitals have four lobes?

- **A** 2
- **B** 3
- **C** 4
- **D** 5
- 3 Which species has the greatest number of unpaired electrons in its ground state?
 - A Cu⁺
 - $\textbf{B} \quad CH_3^-$
 - **C** Mg
 - D F
- 4 Which species contains a dative bond?
 - 1 CO
 - 2 NO₃⁻
 - 3 O₃
 - A 1, 2 and 3
 - **B** 1 and 2 only
 - C 1 and 3 only
 - D 2 only

5 Which row correctly describes the shape and polarity of the species?

	species	shape	polarity
Α	AlCl ₃	trigonal planar	polar
В	SiF ₄	square planar	non-polar
С	BrF₃	trigonal pyramidal	polar
D	BeCl ₂	linear	non-polar

6 Which graph shows the behaviour of a fixed mass of an ideal gas at a constant temperature?



- 7 Which statements explain the difference in ionic radius between Na⁺ and F⁻?
 - 1 Outermost electrons of F⁻ experience weaker nuclear charge than those of Na⁺.
 - 2 Outermost electrons of Na⁺ experience greater shielding effect than those of F^- .
 - 3 Outermost electrons of Na⁺ are nearer to the nucleus than those of F⁻.
 - A 3 only
 - B 1 and 2 only
 - C 1 and 3 only
 - **D** 1, 2 and 3

- 8 0.1 mol of compound X dissolves in 1 dm³ of water to give a solution with a pH of 1.What is the identity of X?
 - A AlCl₃
 - **B** CH₃COC*l*
 - C NH₄NO₃
 - D CH₃COOH
- **9** Wüstite, containing both Fe^{2+} and Fe^{3+} ions, has the formula $Fe_{20}O_x$. Fe^{2+} constitutes 90% of the iron ions present in the compound.

What is the value of *x*?

- **A** 18
- **B** 19
- **C** 21
- **D** 22
- **10** Which option involves a positive entropy change?
 - A the homolytic fission of gaseous chlorine
 - **B** the lattice energy of sodium chloride
 - **C** the contraction of an ideal gas at a constant temperature
 - D cooling a copper strip from 373 K to 273 K

11 The reaction between NO and Br₂ is proposed to proceed via the following mechanism:

step 1: NO + $Br_2 \rightleftharpoons NOBr_2$ (fast)

step 2: $NOBr_2 + NO \longrightarrow 2NOBr$ (slow)

Which statements are correct?

- 1 NOBr₂ is a radical.
- 2 The rate equation for this reaction is rate = $k[Br_2][NO]^2$.
- 3 NOBr₂ is a transition state.
- A 1 and 2 only
- **B** 1, 2 and 3
- C 1 and 3 only
- **D** 2 and 3 only
- **12** Which statement regarding catalysts is correct?
 - **A** Catalysts change the ΔH value of a reaction.
 - **B** Catalysts increase the yield of product in a reaction.
 - **C** Catalysts provide a different mechanism for a reaction.
 - **D** Catalysts change the K_c value of a reaction.
- **13** In aqueous solution, an equilibrium is established between chromate, CrO_4^{2-} (yellow) and dichromate ions, $Cr_2O_7^{2-}$ (orange).

$$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(I)$$

Which statement regarding the ions and the equilibrium is correct?

- **A** The oxidation number of chromium in both chromium-containing ions is different.
- **B** The difference in colour between CrO_4^{2-} and $Cr_2O_7^{2-}$ is due to a difference in energy gap between the 3d orbitals.

C The
$$K_c$$
 expression for the equilibrium is $K_c = \frac{[Cr_2O_7^{2-}][H_2O]}{[CrO_4^{2-}]^2[H^+]^2}$.

D Increasing the pH turns the solution yellow.

14 Nitrogen dioxide dimerises in a closed system and establishes the following equilibrium:

 $2NO_2(g) \rightleftharpoons N_2O_4(g)$

When 46.0 g of NO₂ was introduced into an evacuated rigid vessel with an initial pressure 2 atm at constant temperature, the apparent M_r value of the equilibrium mixture is 64.4.

What is the K_p value of this equilibrium?

- **A** 0.281
- **B** 0.556
- **C** 0.778
- **D** 1.11
- 15 Which solution will solid silver phosphate, Ag₃PO₄, be the least soluble in, at 25 °C?

The numerical value of $K_{sp}(Ag_3PO_4)$ is 8.89×10^{-17} .

- A pure water
- **B** 2.0 mol dm⁻³ AgNO₃(aq)
- **C** 2.0 mol dm⁻³ NH₃(aq)
- **D** 2.0 mol dm⁻³ K₃PO₄(aq)

16 In an acid-base titration, 0.10 mol dm⁻³ solution of an acid is added to 25 cm³ of 0.10 mol dm⁻³ solution of a base.

The pH value of the solution is plotted against the volume, V, of acid added as shown in the diagram.



Which statement is incorrect?

- **A** Maximum buffering capacity occurs at V = 12.5 cm³.
- **B** The pair of solutions could have been HCl(aq) and $CH_3NH_2(aq)$.
- **C** Methyl orange is a suitable indicator for the above titration.
- **D** When the concentration of the acid is doubled, the pH at equivalence point remains unchanged.

17 Some vegetable oils contain 'trans fats' that are associated with undesirable increases in the amount of cholesterol in the blood. In the structures below, R₁ and R₂ are different saturated hydrocarbon chains.

Which structure correctly illustrates an optically active 'trans fat'?



18 A hydrocarbon reacted with bromine under suitable conditions to give the following product.



What type of reaction occurred between the hydrocarbon and bromine?

- **A** electrophilic addition
- **B** free radical substitution
- **C** electrophilic substitution
- **D** nucleophilic addition
- **19** Ferulic acid is an antioxidant that occurs widely in plants.

Assume that the CH_3O- group is inert.



ferulic acid

Which statements about ferulic acid are correct?

- 1 It decolourises aqueous bromine.
- 2 It is not very soluble in water but dissolves in aqueous NaOH.

It can be prepared from HO – CH=CHCH₂OH using hot acidified K₂Cr₂O₇ (aq). H_3 CO

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

20 Unsaturated carbonyl compounds can undergo a useful reaction known as the Diels-Alder reaction with a diene. An example is shown below.



A student reacted the following diene and carbonyl compound together in a Diels-Alder reaction.



Which product will not be formed?







21 Deuterium, D, is a heavy isotope of hydrogen. Deuteriobenzene reacts with chlorine and $AlCl_3$ under controlled conditions so that only monochlorination takes place.

Assuming that the carbon-deuterium bond is broken as easily as a carbon-hydrogen bond, what is the proportion of 2-chlorodeuteriobenzene in the mono-chlorinated products?



22 Two female sex hormones are oestrone and oestradiol.



Which reagents could be used to distinguish between the two hormones?

- 1 SOC l_2
- 2 2,4-dinitrophenylhydrazine
- 3 LiA*l*H₄ in dry ether
- **A** 1 and 2 only **B** 1 only **C** 2 and 3 only **D** 1, 2 and 3
- **23** Many different compounds have been used in aerosol sprays, refrigerators and in making foamed plastics.

Which compound will cause the most ozone depletion?

- A CCl₃F
- B CH₂FCHC*l*F
- C CH₃CH₂CH₂CH₃
- **D** $CH_2=CHCl$

24 Which reagent reacts with the following organic compound to give only one organic product?

Assume that the CH₃O- group is inert.



- A hot NaOH(aq)
- **B** hot acidified K₂CrO₇(aq)
- $\mathbf{C} = H_2(g), Pt$
- **D** HCl(g)
- **25** The amino acids glutamine and glutamic acid can react with each other to form amide linkages.



glutamine



What is the maximum number of different compounds that can be formed from one molecule of glutamine and one molecule of glutamic acid?

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

26 0.01 mol of KIO_n reacts with 0.05 mol of KI stoichiometrically to produce I_2 under acidic conditions.

In this reaction, all the iodine containing reactants were converted to $I_2(aq)$.

What is the value of n?

- **A** 1
- **B** 2
- **C** 3
- **D** 4

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

By considering relevant E^{\bullet} values, which metal will not dissolve in 1 mol dm⁻³ HC*l*(aq)?

- **A** V **B** Ag **C** Mg **D** Sn
- **28** The Kolbe reaction involves decarboxylative dimerisation of carboxylate ions by electrolysis. When an aqueous solution of sodium carboxylate is electrolysed, the overall equation is as follows:

 $2RCO_2Na + 2H_2O \longrightarrow R-R + 2CO_2 + 2NaOH + H_2$ where $R = C_nH_{2n+1}$

Which statements about the anode and cathode are correct?

	anode	cathode	
1	The solution around the anode turns moist blue litmus red.	The solution around the cathode turns moist red litmus blue.	
2	RCO ₂ Na is oxidised to R–R at the positive terminal.	H_2O is reduced to H_2 at the negative terminal.	
3	The standard electrode potential involving H_2O is the least positive.	The standard electrode potential involving H_2O is the most positive.	

- **A** 1 only **B** 1 and 2 only **C** 2 and 3 only **D** 1, 2 and 3
- 29 Use of the *Data Booklet* is relevant to this question.

15.7 g of the metal gadolinium (Gd) was deposited in electrolysis by a current of 5.0 A for 96.5 minutes.

What is the formula of the gadolinium ion? [A_r of Gd = 157]

30 X is a transition metal. Under a high concentration of Cl^- , the cation of **X** forms a coloured complex ion, $[\mathbf{X}Cl_4]^{2^-}$. When $[\mathbf{X}Cl_4]^{2^-}$ is reduced to $[\mathbf{X}Cl_2]^-$, the solution turns colourless.

What is the ground state electronic configuration of X?

A [Ar] $3d^5 4s^1$ **B** [Ar] $3d^{10} 4s^1$ **C** [Ar] $3d^5 4s^2$ **D** [Ar] $3d^9 4s^2$