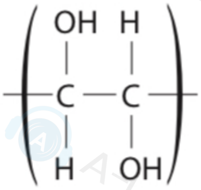
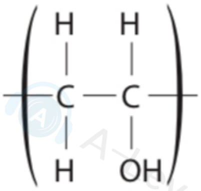
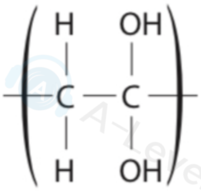
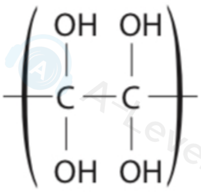
14 What is the repeat unit of the water-soluble polymer poly(ethenol)?

☒ **A** 

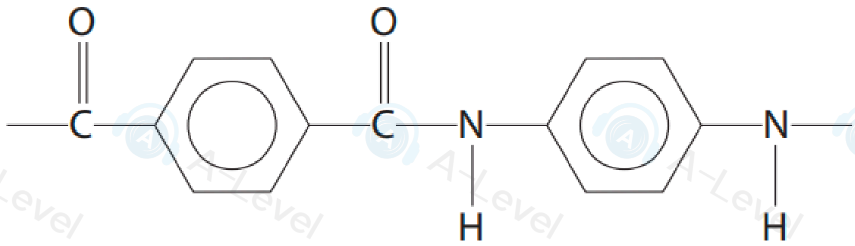
☒ **B** 

☒ **C** 

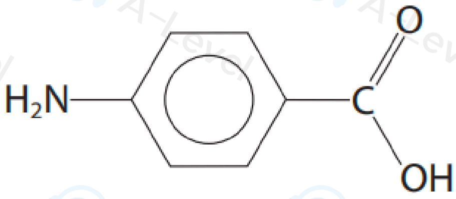
☒ **D** 

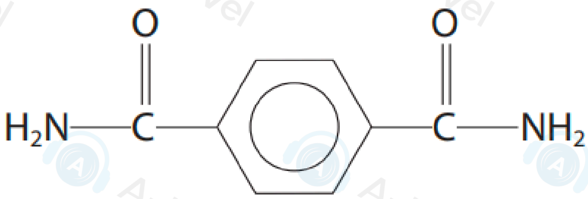
(Total for Question 14 = 1 mark)

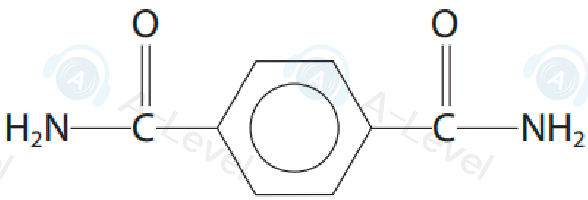
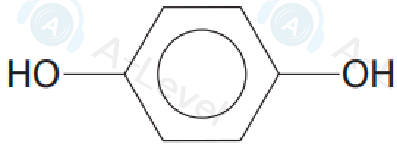
14 A polyamide has the repeat unit

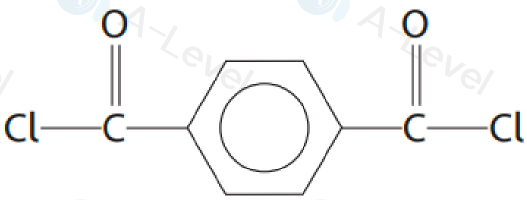
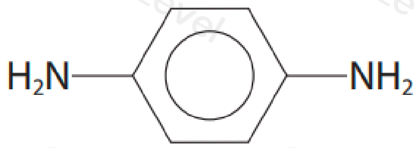


Which of these monomers can form this polyamide?

☒ **A**  only

☒ **B**  only

☒ **C**  and 

☒ **D**  and 

2 Some standard electrode potentials are shown.

Right-hand electrode system	$E^{\ominus}$ / V
$Mg^{2+} + 2e^- \rightleftharpoons Mg$	−2.37
$Ce^{3+} + 3e^- \rightleftharpoons Ce$	−2.33
$Mn^{2+} + 2e^- \rightleftharpoons Mn$	−1.19
$Mn^{3+} + e^- \rightleftharpoons Mn^{2+}$	+1.49
$Ce^{4+} + e^- \rightleftharpoons Ce^{3+}$	+1.70

Which reaction is thermodynamically feasible?

☒ **A** $2Ce + 3Mg^{2+} \rightarrow 2Ce^{3+} + 3Mg$

☒ **B** $4Ce^{3+} \rightarrow Ce + 3Ce^{4+}$

☒ **C** $3Mn^{2+} \rightarrow Mn + 2Mn^{3+}$

☒ **D** $Mg + 2Ce^{4+} \rightarrow Mg^{2+} + 2Ce^{3+}$

3: Which reaction occurs at an electrode in a hydrogen-oxygen fuel cell?

☒ **A** $O_2(g) + 2H_2(g) \rightarrow 2H_2O(l)$

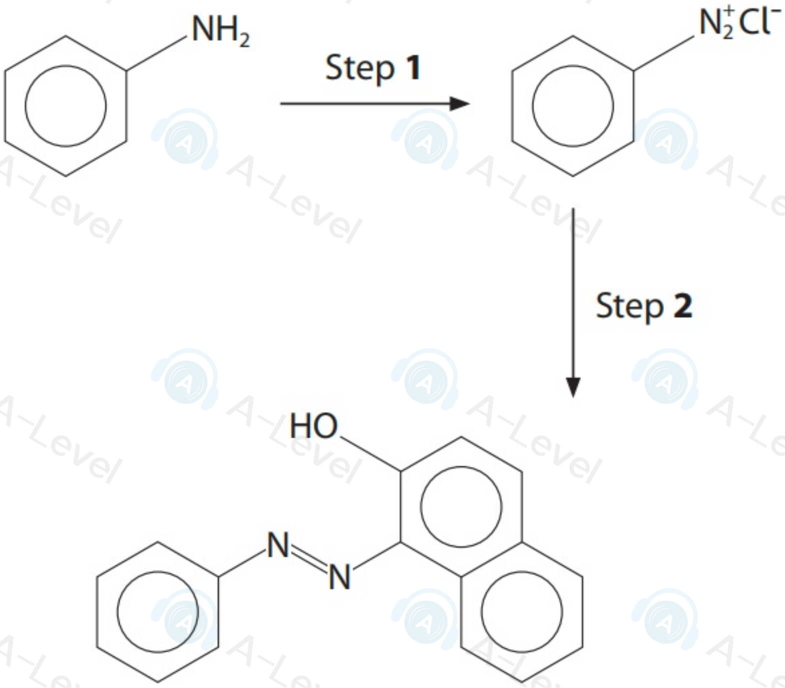
☒ **B** $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$

☒ **C** $4H^+(aq) + 4OH^-(aq) \rightarrow 4H_2O(l)$

☒ **D** $H_2O(l) + 2OH^-(aq) \rightarrow 2H_2(g) + 1\frac{1}{2}O_2(g) + 2e^-$

(Total for Question 3 = 1 mark)

15 A reaction scheme for the preparation of an azo dye from phenylamine is shown.



(a) What are the reagents and condition for Step **1**?

(1)

☒ **A** $NaNO_2$ and HCl at 5 °C

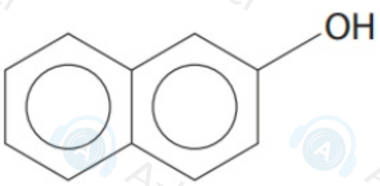
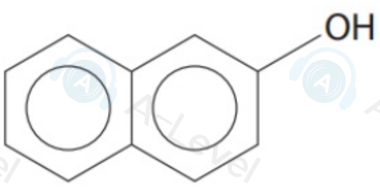
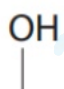
☒ **B** $NaNO_3$ and HCl at 5 °C

☒ **C** $NaNO_2$ and HCl at 50 °C

☒ **D** $NaNO_3$ and HCl at 50 °C

(b) Which reagent and condition are used for Step **2**?

(1)

	Reagent	Condition
☒ **A**		acidic
☒ **B**		alkaline
		

1 What is the electronic configuration of the chromium **atom**?

☒ **A** [Ar] $3d^4$ $4s^2$

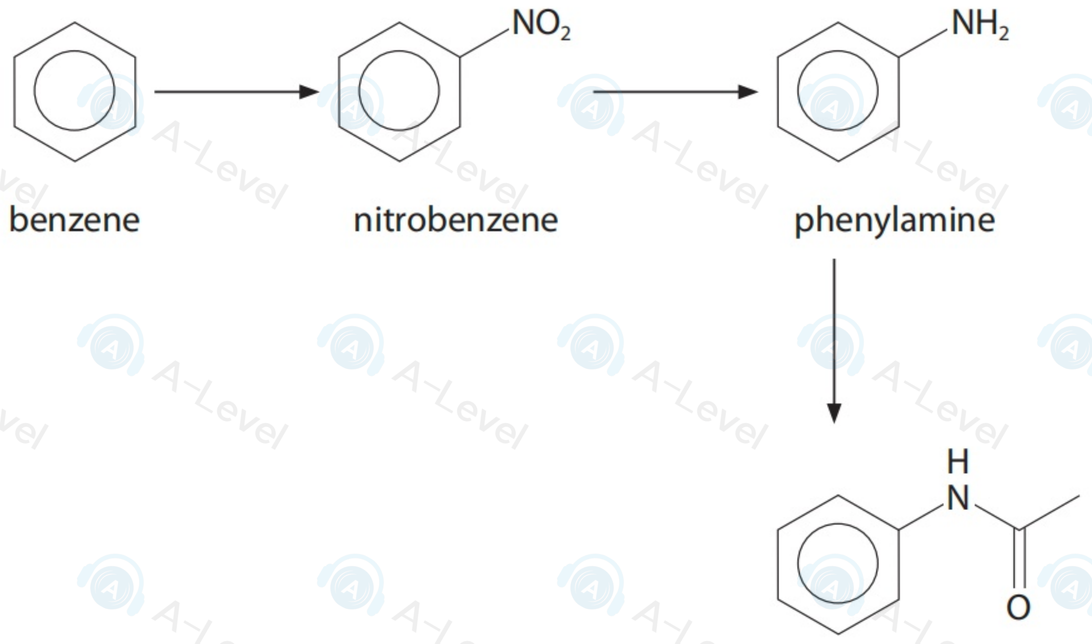
☒ **B** [Ar] $3d^5$ $4s^1$

☒ **C** [Ar] $3d^6$

☒ **D** [Ar] $3d^1$ $4s^2$ $4p^3$

(Total for Question 1 = 1 mark)

14 *N*-phenylethanamide, historically used as a painkiller, can be synthesised from benzene as shown.



N-phenylethanamide

(a) Concentrated nitric acid reacts with a second reagent to produce an electrophile. This electrophile reacts with benzene to form nitrobenzene.

(i) Identify, by name or formula, the second reagent and the electrophile.

(2)

....

....

(ii) Draw the mechanism for the reaction between the electrophile and benzene to form nitrobenzene.

(3)

*(c) In the final step of the synthesis, phenylamine reacts with either ethanoyl chloride or ethanoic anhydride.

phenylamine + ethanoyl chloride → *N*-phenylethanamide + hydrogen chloride

phenylamine + ethanoic anhydride → *N*-phenylethanamide + ethanoic acid

Ethanoyl chloride is considerably more reactive than ethanoic anhydride.

Hazard symbols for reactants and products are shown.

Compound	Hazards
phenylamine	
ethanoic anhydride	
ethanoyl chloride	

Compound	Hazards
N-phenylethanamide	
ethanoic acid	
hydrogen chloride	

Assess the advantages and disadvantages of the use of ethanoic anhydride rather than ethanoyl chloride for this reaction.

Consider the hazards associated with the reactants and products, and the atom economy of each reaction.

(6)

(d) The overall yield for the synthesis of *N*-phenylethanamide from benzene was found to be 35.2%.
Calculate the minimum volume of benzene, in cm^3, required to make 10.0 g of *N*-phenylethanamide.
[Density of benzene = $0.879\ g\ cm^{-3}$]

(4)

Manganese and some of its compounds

Manganese is the twelfth most abundant element in the Earth's crust and it is an essential element for all living organisms.

Manganese is a transition metal and it can form compounds with oxidation states +2, +3, +4, +5, +6 and +7, although not all these are stable and some readily undergo disproportionation.

Some compounds and ions containing manganese are effective heterogeneous and homogeneous catalysts.

Alkaline batteries have a manganese(IV) oxide cathode and are used in digital cameras and toys. They have a similar voltage to traditional zinc-carbon batteries but have a higher energy density and last longer.

(a) Some of the properties of manganese and its compounds depend on electronic configurations.

(i) Complete the electronic configurations for a manganese atom and a manganese(II) ion, using the electron-in-boxes notation.

(1)

	3d						4s
Mn atom: [Ar]							
Mn^{2+} ion: [Ar]							

(ii) The standard electrode potentials, $E^{\ominus}$, for the half-cells involving the oxidation states +3 and +2 for manganese and iron are shown.

$$Mn^{3+}(aq) + e^- \rightleftharpoons Mn^{2+}(aq) \qquad E^{\ominus} = +1.49\,V$$

$$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq) \qquad E^{\ominus} = +0.77\,V$$

Explain, in terms of electronic configurations, why the $E^{\ominus}$ value for the Mn^{2+}/Mn^{3+} half-cell is significantly higher than that for the Fe^{2+}/Fe^{3+} half-cell.

(3)

(ii) Manganese(IV) oxide catalyses the decomposition of hydrogen peroxide.

$$2H_2O_2(aq) \rightarrow 2H_2O(aq) + O_2(g)$$

100 cm^3 of a solution of hydrogen peroxide decomposed to produce 86.0 cm^3 of oxygen gas, measured at room temperature and pressure (r.t.p.).

Calculate the concentration of the hydrogen peroxide solution in $mol\,dm^{-3}$.

[Molar volume of gas at r.t.p. = 24.0 $dm^3\,mol^{-1}$]

(2)

(c) Potassium manganate(VI), K_2MnO_4, is a green solid.
In acidic solution, the manganate(VI) ions disproportionate to form manganate(VII) ions and manganese(IV) oxide.

Write the **ionic** equation for this disproportionation.
State symbols are not required.

(1)

(d) Manganate(VII) ions react with ethanedioate ions in acidic solution.

$$2MnO_4^-(aq) + 16H^+(aq) + 5C_2O_4^{2-}(aq) \rightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 10CO_2(g)$$

Two experiments were carried out:

Experiment 1
Aqueous potassium manganate(VII) was added to a mixture of excess ethanedioic acid and sulfuric acid. The concentration of the manganate(VII) ions was determined as the reaction progressed.

Experiment 2

(e) Methylbenzene is oxidised to benzoic acid by heating under reflux with an alkaline solution of potassium manganate(VII).

In an experiment, 1.73 g of methylbenzene was mixed with 7.00 g of potassium manganate(VII) and excess potassium hydroxide solution.

The overall equation is

$$2MnO_4^- + C_6H_5CH_3 \rightarrow 2MnO_2 + C_6H_5COO^- + OH^- + H_2O$$

(i) Show that the potassium manganate(VII) is in excess.

[Molar masses / g mol^{-1}: $C_6H_5CH_3 = 92$ $KMnO_4 = 158$]

(3)

(ii) State how the benzoate ions, $C_6H_5COO^-$, can be converted into benzoic acid.

(1)

(f) Alkaline batteries consist of an anode made of a zinc alloy, a cathode made of manganese(IV) oxide and an electrolyte of aqueous potassium hydroxide.

The overall equation for the reaction in the cell is

$$2MnO_2(s) + Zn(s) \rightleftharpoons Mn_2O_3(s) + ZnO(s) \qquad E^{\ominus}_{cell} = +1.43\,V$$

(i) Write the half-equations for the reactions at the anode and the cathode.