Q1.

4	(a)	Cl_2 + light/heat	(aq negates)	[1]	
					1
	(b)	Cl_2 + $AlCl_3$/$FeCl_3$/Fe etc.	(aq negates)	[1]	
					1
	(c)	 CO_2H			
				[1]	
					1
	(d)	NaOH + I_2 (+ aq)	(*or* I^- + OCl^- + aq)	[1]	
		C: (pale) yellow ppt. **D**: no reaction	(**both**)	[1]	
					2
	(e)	mass of *CN* needed = 0.03 x 60 = 1.8g		[1]	
		M_r = 154.5, ∴ amount = 1.8/154.5 = **0.0117** (mol) (allow **0.012**)		ecf [1]	
					2
	(f)	(i) increasing ease: H < D < G		[1]	
		(ii) chlorine on the aryl ring is very inert *or* strong C-C*l* bond *or* overlap between C*l* lone pair and π bond on ring (OWTTE)		[1]	
		chlorine on C=O is reactive because of highly δ+ carbon atom bonded to electronegative O and C*l* (OWTTE)		[1]	
					3

Q2.

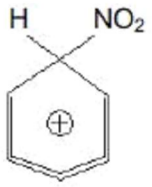
5 (a) (i) Cl_2 + $AlCl_3$ etc. (UV *or* aq negates) [1]

(ii) Br_2 + $AlCl_3$ *or* $AlBr_3$ etc. [1]

(iii) HNO_3 + H_2SO_4 [1]
conc. + 50° < T < 60° [1]

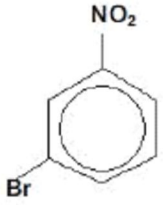
(b) (i) A^+ = NO_2^+ *or* nitronium ion [1]

(ii) B is

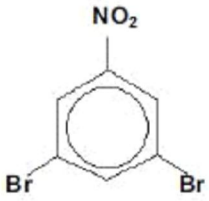


[1]

(c) (i)

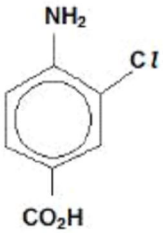


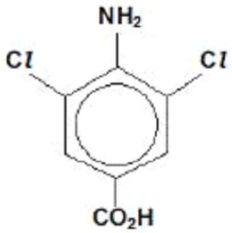
or



[1]

(ii)





[1]

Total = [8]

Q3.

(c) **(i)** Cl_2(**aq**) $AlCl_3$ or UV negates **[1]**

(ii) Electrophilic substitution **or** addition-elimination **[1]**

Nucleophilic substitution **or** electrophilic substitution on OH group
If neither mark is awarded, could give "salvage" mark for substitution x2 **[1]**

(iii) **Either:** add Br_2(**aq**) phenol decolourises it, or gives a white ppt.
or: add $FeCl_3$(**aq**) phenol give a purple colour
or: add NaOH(**aq**) phenol dissolves
or: add UI solution phenol goes yellow/orange (**A** stays green)
or: add "diazonium" to solution in OH^-
phenol gives orange/red colour
(in each case, **A** give no reaction)

or: add $Cr_2O_7^{2-}/H^+$/warm **A** changes colour from orange to green
or: add MnO_4^-/H^+/warm **A** changes from purple to colourless
or: add $PCl_5/POCl_3/PCl_3/SOCl_2$ **A** gives fumes
or: add CH_3CO_2H + conc. H_2SO_4 **A** gives fruity smell

(in each case, no change with phenol)

Test + reagents **[1]** **Both** observations **[1]**

Part (c): [5]

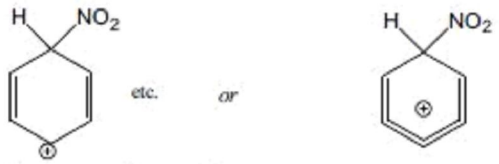
Q4.

6 (a) (i) Electrophilic substitution **or** nitration **[1]**

(ii) $HNO_3 + H_2SO_4$ **[1]**

(both) conc., and at 50°C ≤ T ≤ 60°C **[1]**

(iii) NO_2^+ **[1]**



Any ⊕ on NO_2 or H negates **[1]**

H^+ **[1]**

Part (a): [6]

(b) (i) Reduction **[1]**

(ii) Sn/Fe/Zn/$SnCl_2$ + HCl/H^+/H_2SO_4 (but not conc. H_2SO_4)
or H_2 + Ni/Pt (**not** $LiAlH_4$) **[1]**

Part (b): [2]

(c) PCl_5/PCl_3/$SOCl_2$/$POCl_3$ (+ heat) aq negates **[1]**

Part (c): [1]

(d) (i) An amide, **not** peptide **[1]**

(ii) Heat with H_3O^+ **or** heat with OH^-(**aq**)

Or warm (**not** heat/reflux) with aqueous amidase/peptidase/protease **not** enzyme/trypsin/chymotrysin/pepsin/papain etc. **[1]**

Part (d): [2]

Q5.

5 **(a)** I: $HNO_3 + H_2SO_4$ (*or* names) [1]

(both) conc. and at $50^\circ C < T < 60^\circ C$ ✓ [1]

II: $KMnO_4$ ($+OH^-$) + heat [1]

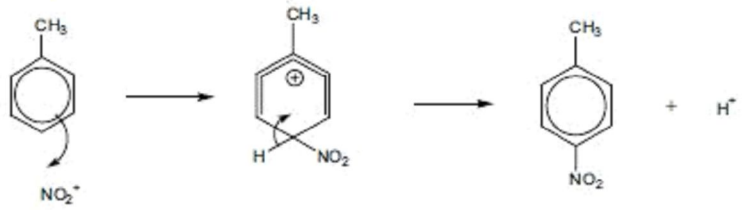
III: Sn + (conc) HC*l* [1]

IV: CH_3CH_2OH (*or* name) [1]

+ c. H_2SO_4 + heat [1]

[6]

(b)



intermediate, including ⊕ [1]

NO_2^+ at start and H^+ at finish [1]

(no marks for curly arrows, but if present, they must be in correct direction)

[2]

(c) **(i)** ester and (primary) amine [2]

(ii) **more** basic: amine group is *not* adjacent to benzene ring **both** points [1]
(*or* lone pair (on N) is not delocalised)

[3]

[Total: 11]

Q6.

5 **(a)** I: Cl_2 + $AlCl_3$/Fe/etc [1]
II: Cl_2 + *hf* [1]
III: $KMnO_4 + H^+$ [1]
IV: $SOCl_2$ *or* PCl_5/PCl_3 *or* P + Cl_2 [1]
(for I, II and IV, deduct a mark ([1] only) for one or more mentions of (aq))
(for I, mention of hf negates the mark)
(for I and II, if Cl_2 is omitted in one or both, deduct [1] mark only) **[4]**

(b) I: electrophilic substitution [1]
III: oxidation *or* redox (NOT oxygenation) [1] **[2]**

(c) **H** is C_6H_5-CH_2CN [1]
step V: NaCN/KCN [1]
heat (*or* 50-80°C) + ethanol/alcohol [1]
step VI: $LiAlH_4$ *or* H_2 + Ni/Pt/Pd/Rh *or* Na + ethanol [1] **[4]**

(d)

compound	reagent	
	cold water	hot NaOH(aq)
E	***no reaction***	***no reaction***
F	***no reaction***	$C_6H_5CH_2OH$
G	$C_6H_5CO_2H$	$C_6H_5CO_2^-Na^+$

6 x [1] **[6]**

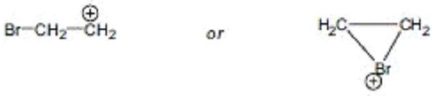
[Total: 16]

Q7.

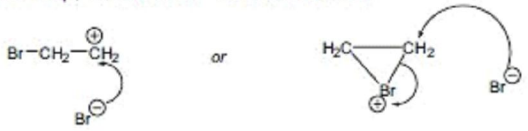
5 **(a)** reaction I electrophilic addition [1]

reaction II electrophilic substitution [1]
(salvage: award [1] out of [2] for "addition" + "substitution", even if nucleophilic) **[2]**

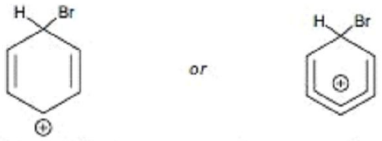
(b) reaction I: intermediate [1]



second step, attack of Br^- on bromocation. [1]

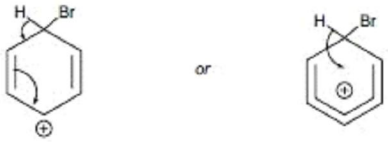


reaction II: intermediate [1]



(*or* with ⊕ in 2-position) (make sure ⊕ is not at sp^3 C-atom)

second step, loss of H^+ from bromocation. [1]



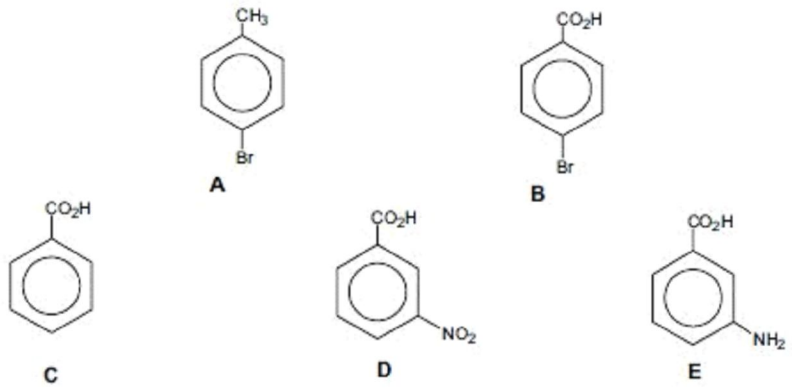
[4]

(c) **Delocalised** ring of electrons (in benzene) is **stable**, (so is re-formed in second step in benzene.)
or electrons in the ethene π bond are localised/more available for reaction with electrophiles
[1] **[1]**

[Total: 7]

Q8.

6



5 x [1]

[deduct [1] mark if ring circle omitted more than once]
[allow ecf for **E** from structure of **D**]
[allow ecf for **B** from structure of **A**]
[allow $-CO_2^-$ for **E**] **[5]**

[Total: 5]

Q9.

6 **(a)** **(i)** I: $SOCl_2$ *or* PCl_5 *or* $HCl + ZnCl_2$ *or* PCl_3 + heat *or* Cl_2 + P + heat [1]
[**NOT** $NaCl + H_2SO_4$]
(mention of aq negates mark)

II: NH_3 (ignore any conditions stated) [1]

(ii) nucleophilic substitution *or* S_N *or* S_N1 *or* S_N2 [1]

(iii) delocalisation of lone pair on Cl over benzene ring produces a stronger C-Cl bond [1]
[4]

(b) **(i)** III: $HNO_3 + H_2SO_4$ [1]

both conc., and at $T < 60^oC$ [1]

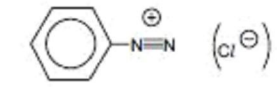
IV: Sn + **conc** HCl [**NOT** $LiAlH_4$ or H_2 + Ni] [1]

(ii) III: electrophilic substitution [1]

IV: reduction *or* redox [1]
[5]

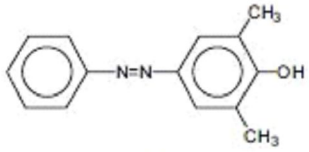
(c) e.g. add bromine water *or* $Br_2(aq)$ (a solvent is needed for the mark) [1]
or add UI solution
phenylamine decolorises the bromine *or* gives a white ppt., hexylamine does not [1]
or hexylamine turns UI blue, with phenylamine it stays green
[2]

(d)



(allow + charge on either N)
(allow double or triple bond)

[1]



(phenylazo group must be at 4-position to -OH)
(N=N must be double bond, not triple)

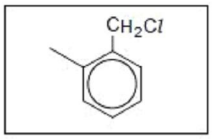
[1]

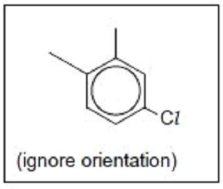
[2]

[Total: 13]

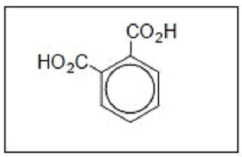
Q10.

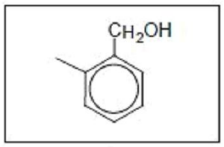
7

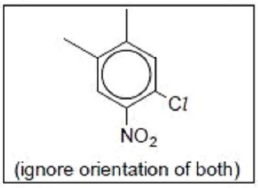




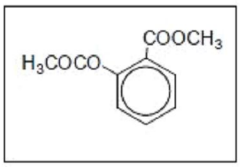
(ignore orientation)







(ignore orientation of both)

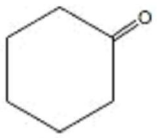


[6]

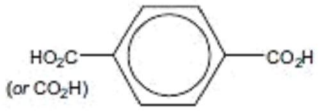
[Total: 6]

Q11.

(d)



(1) and CH_3CO_2H (1)



(1)

(1)

or

(1)

[5]

(e) (i) $(CH_3)_2C(OH)–CH_2OH$ (1)

(ii) reaction I: (cold dilute) $KMnO_4$ ("cold" not needed, but "hot" or "warm" negates) (1)
reaction II: $Cr_2O_7^{2-} + H^+$ + **distil** (1) [3]

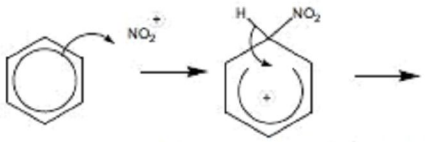
Q12.

5 (a) (i) because the carbons are sp^2 / trigonal planar / bonded at 120° *or* are joined by π bonds / orbitals (1)

(ii) because the π electrons / double bonds are delocalised / in resonance *or* electrons are evenly distributed / spread out (1) [2]

(b) (i) $HNO_3 + 2H_2SO_4 \rightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$ (1)
or $HNO_3 + H_2SO_4 \rightarrow H_2NO_3^+ + HSO_4^-$ *or* $\rightarrow H_2O + NO_2^+ + HSO_4^-$

(ii) electrophilic substitution (1)
mechanism:



curly arrows from benzene to NO_2^+, **and** showing loss of H^+ (1)
correct intermediate (with "+" in the 'horse-shoe') (1) [4]

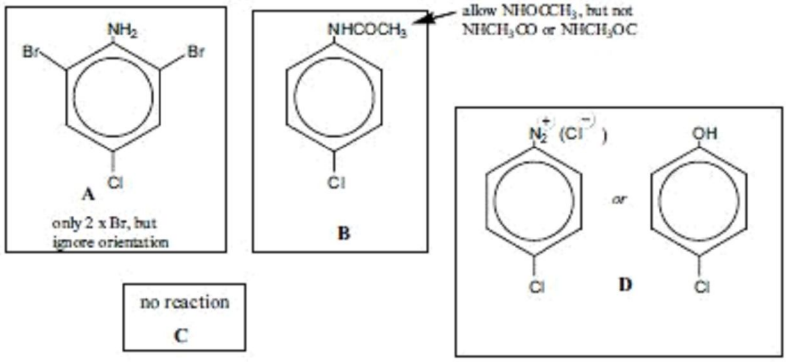
(c) Cl_2 + $AlCl_3$ / $FeCl_3$ / Fe / Al / I_2 (aq or light negates this mark) (1) [1]

(d) (i) **Y** is chlorobenzene (1) **Z** is 4-chloronitrobenzene (1) (2)

(ii) Sn / Fe + (conc) HC*l* (1)

HC*l* is **conc**, **and** second step is to add NaOH(aq) (1)

(iii)

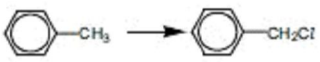


(4) [8]

[Total: 15]

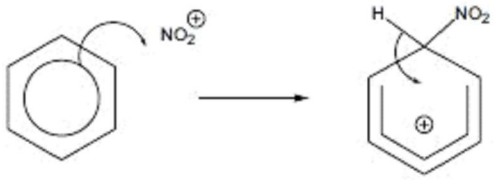
Q13.

5 (a)

transformation	reagent + conditions
$C_2H_4 \rightarrow C_2H_5Cl$	**HC*l*, no light or catalyst**
$C_2H_5OH \rightarrow C_2H_5Cl$	**conc HC*l* + ZnC*l*$_2$ *or* SOC*l*$_2$ *or* PC*l*$_5$ *or* PC*l*$_3$ and heat**
$C_2H_6 \rightarrow C_2H_5Cl$	**C*l*$_2$ + light**
$C_2H_4 \rightarrow C_2H_4Cl_2$	**C*l*$_2$, no light or catalyst**
$CH_3CO_2H \rightarrow CH_3COCl$	**SOC*l*$_2$ *or* PC*l*$_5$ *or* PC*l*$_3$ and heat**
	**C*l*$_2$ + A*l*C*l*$_3$**
	**C*l*$_2$ + light or heat**

[6]

(b) (i) production of NO_2^+: $2H_2SO_4 + HNO_3 \rightarrow 2HSO_4^- + H_3O^+ + NO_2^+$ [1]
(accept $H_2SO_4 + HNO_3 \rightarrow HSO_4^- + H_2O + NO_2^+$)



curly arrow from ring to NO_2^+ **and** from C-H bond to ring [1]
correct intermediate, including charge in the right place [1]
Note charge area must be more than half ring

(ii) **C** is $C_6H_5CO_2H$ [1]

(iii) step 1: reagent is hot acidified or alkaline $KMnO_4$ [1]
step 2: reagent is Br_2 + $FeBr_3$/$AlCl_3$ etc. (H_2O or light negates) [1]

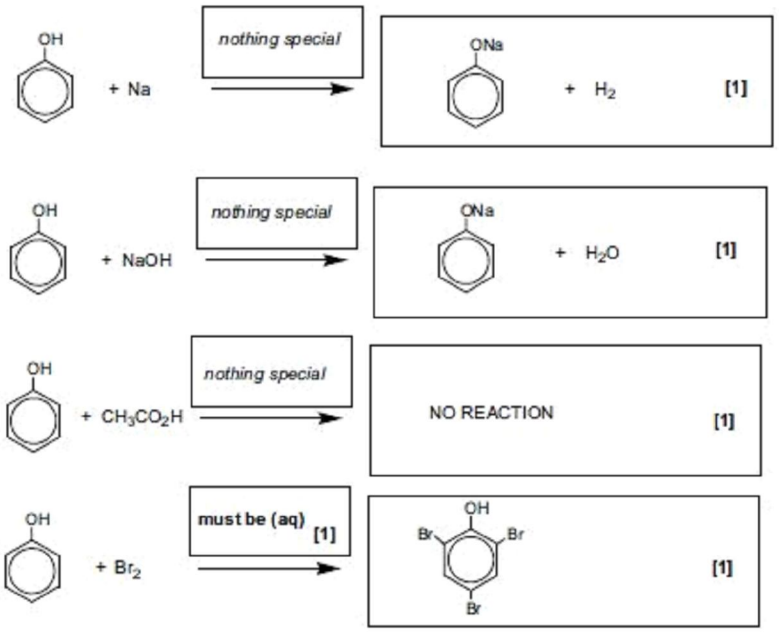
(If **C** is given as 3-bromotoluene, then allow the last [2] marks if steps 1 and 2 are reversed.)

[Total: 12]

Q14.

5 **(a)** acidity: ethanol < water [1]
due to +ve inductive effect of C_2H_5 group *or* C_2H_5 gives e^- to oxygen *or* intensifies e^- (in O-H bond) [1]
acidity: phenol > water [1]
due to stabilisation of the anion/anionic charge *or* makes the anion less basic [1]
[4]

(b)



[5]

(c) **H** is

[1]

reagents & conditions:
step 1 **dilute** HNO_3 (dilute, not just 'aq'. H_2SO_4 negates) [1]

step 2 Sn/$SnCl_2$/Fe + HCl *or* H_2 + Ni/Pd (NOT H_2 + Pt. NOT $LiAlH_4$ or $NaBH_4$) [1]

step 3 CH_3COCl *or* $(CH_3CO)_2O$ ('aq.' negates) [1]
[4]

[Total: 13]

Q15.

3. (a) (i) $C_{16}H_{10}N_2O_2$ [1]

(ii) ketone, alkene, amine, aryl (benzene/arene/phenyl) (**any 3**) [2]
[3]

(b) (i) reduction *or* redox [1]

(ii) $NaBH_4$ or $LiAlH_4$ (**NOT** H_2 + Ni) [1]
[2]

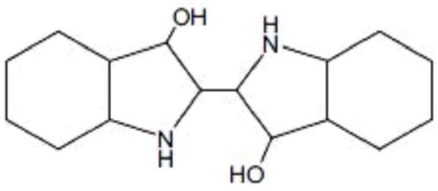
(c) 1. 2,4-DNPH [1] red/yellow-orange/orange ppt. [1] no reaction

2. Na metal [1] no reaction gas given off/fizzing [1]

or PCl_5/$SOCl_2$ [1] *no reaction* *steamy fumes/fizzing [1]*
or PCl_3 + warm *misty/white fumes*

2 x "no reaction" must be linked to "correct reagent" [1]
[5]

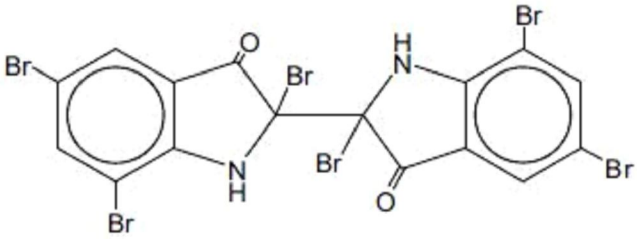
(d) (i)



[1]

(ii) M_r = 262, so 2.5 g = 2.5/262 = 9.54×10^{-3} mol [1]
(1 mol indigo absorbs 9 mol of H_2)
so volume of $H_2 = 9 \times 24 - 9.54 \times 10^{-3}$ = **2.06 dm^3** (2060 cm^3)
[1]
[3]

(e)

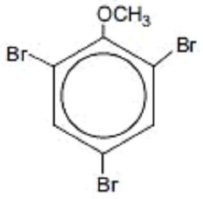


2 x Br **on C=C** [1]
a Br on each ring [1]
TWO non-adjacent Br on **each ring** [1]
[3]

[Total: 16]

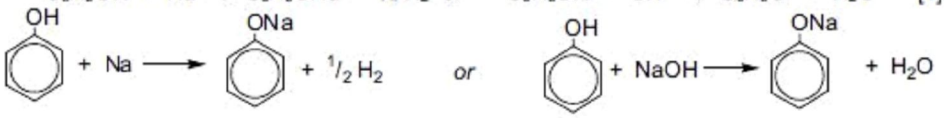
Q16.

5 (a) (i)



[1]

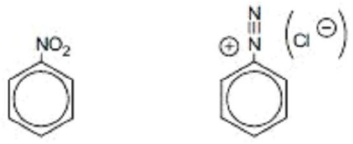
(ii) Na metal *or* NaOH [1]
Fizzes/gas given off with phenol *or* phenol dissolves (anisole doesn't) [1]
$C_6H_5OH + Na \rightarrow C_6H_5ONa + ½ H_2$ *or* $C_6H_5OH + OH^- \rightarrow C_6H_5O^- + H_2O$ [1]



(neutral) iron(III) chloride *[1]*
Solution goes purple/violet *[1]*
$3C_6H_5OH + FeCl_3 \rightarrow Fe(OC_6H_5)_3 + 3HCl$ *[1]*

[4]

(b) (i)



D E

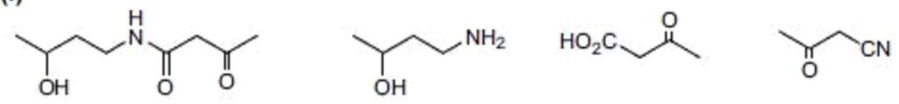
[1] + [1]

(ii) step 2: Sn + HCl **NOT** $LiAlH_4$, $NaBH_4$ [1]
conc. + reflux *(warm is insufficient)* [1]

step 4 is conditional of structure E
step 4: warm + in H_2O [1]

[5 max 4]

(c) (i)



F G H J

F must be an **amide**

[4]

(ii) reaction 1: H_2 + Ni *or* $LiAlH_4$ [1]
reaction 2: heat + aqueous HCl [1]

[6]

[Total: 14]

Q17.

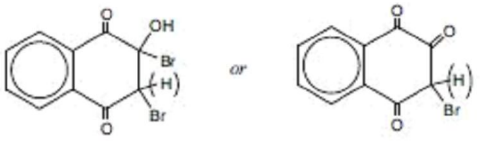
3 (a) (i) ketone, alcohol, alkene, arene/aryl/benzene/phenyl. any three [2]
(if more than 3 are given, mark the first 3 the candidate has written)

(ii)

(2,4-)DNPH/Brady's	*or* $FeCl_3$ (aq or neutral)	*or* Br_2(**aq**)	[1]
Lawsone ⇒ orange/red, (not yellow) ppt	*or* purple/violet with **A**,	*or* white ppt with **A**,	[1]
and A ⇒ nothing	*or* **and** nothing with Lawsone	*or* **and** decolourises with Lawsone	

(iii) $NaBH_4$ *or* $LiAlH_4$ *or* $SnCl_2$ *or* Na + ethanol *or* any suitable reducing agents with $E^{\ominus} < 0.2\,V$, e.g. SO_2. **NOT** H_2 + Ni etc. [1]

(iv)



(One of the Br atoms in either formula could be an OH group instead. Br on the **benzene** ring negates this mark)

[1]
[6]

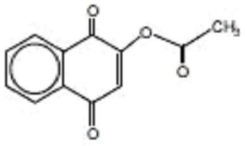
(b) (i) $E_{cell} = 1.33 - 0.36 =$ **(+)0.97 (V)** [1]

(ii) $Cr_2O_7^{2-} + 8H^+ + 3C_{10}H_8O_3 \rightarrow 2Cr^{3+} + 7H_2O + 3C_{10}H_6O_3$

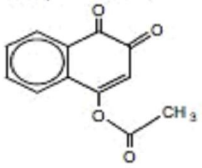
3:1 ratio [1]
balancing [1]

(iii) $= 0.05 \times 7.5/1000 = 3.75 \times 10^{-4}$ mol [1]
$n(\mathbf{A}) = 3 \times 3.75 \times 10^{-4}$
$= 1.125 \times 10^{-3}$ in 20 cm^3
$[\mathbf{A}] =$ **5.63×10^{-2}** mol dm^{-3} (allow 5.6, 5.62, 5.625 etc.) [1]
[5]

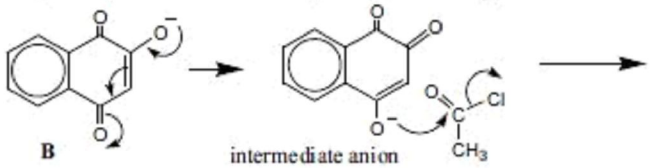
(c) (i) compound **C** is [1]



(ii) compound **D** is [1]



(iii) mechanism: 3 curly arrows in **B** *or* correct intermediate anion [1]
a curly arrow from an O^- or an oxygen with a lone pair to the carbon of the C=O group in CH_3COCl, and a second curly arrow breaking the C-Cl bond [1]

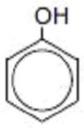
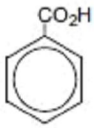
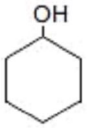


[4 max 3]

[Total: 14]

Q18.

5 (a)

	H_2O			
Na	H_2	**H_2**	**H_2**	**H_2**
KOH(aq)	X	**X**	**X**	**X**
Na_2CO_3(aq)	X	**X**	**CO_2**	**X**

[5]

(b) (i) $(CH_3)_3C–Cl$ (any unambiguous structure *or* name) [1]

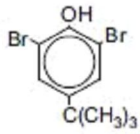
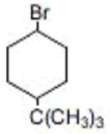
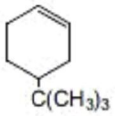
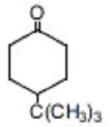
(ii) reduction *or* hydrogenation [1]

(iii) *either* CH_3CO_2H **and** heat with (conc) H_2SO_4
or
CH_3COCl [1]

(iv) reflux [1]

dilute HCl [1]
[5]

(c) (i)

reagent and conditions	product with **A**	product with **B**
$Br_2(aq)$		no reaction
heat with HBr	no reaction	
pass vapour over heated Al_2O_3	no reaction	
heat with acidified $K_2Cr_2O_7$	no reaction	

[6]

(ii) *either:* $Cr_2O_7^{2-}/H^+$: no observation with **A and** goes from orange to green with **B.**
or:
$Br_2(aq)$: white ppt. with **A and** no observation/ppt with **B** [1]
[7]

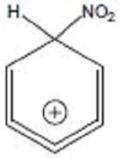
[Total: 17]

Q19.

3 **(a) (i)** $HNO_3 + H_2SO_4$ [1]
conc (both acids) **and** 30°C < T < 60°C *or* warm [1]

(ii) dilute HNO_3 *or* HNO_3(aq)
and room temp. (allow T ≤ 30°C) [1]
[3]

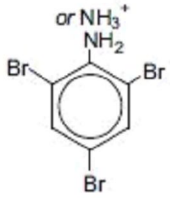
(b) (allow intermediate from methylbenzene)



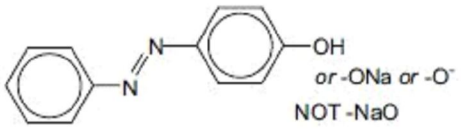
[1]
[1]

(c) Sn/tin (*or* $SnCl_2$, Fe) + HC*l* (NOT H_2SO_4 *or* H^+, Zn, *or* $LiAlH_4$.) [1]
[1]

(d) (i)



A



B

[1] + [1]

(ii) $NaNO_2$ + HC*l* *or* H_2SO_4 *or* H^+ *or* HNO_2 [1]

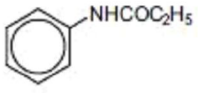
T ≤ 10°C [1]
[4 max 3]

(e) (i) amide [1]

(ii) M_r = 108+11+14+16 = 149

%N = (14 x 100)/149 = 9.4% [1]

(iii)



[1]
[3]

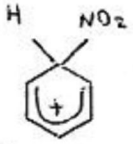
[Total: 11]

Q20.

5 (a) $HNO_3 + H_2SO_4$ [1]
conc acids (aq negates) **and** T between 50 - 60° C [1]
2

(b) electrophilic substitution [1]
1

(c) (i) structure:

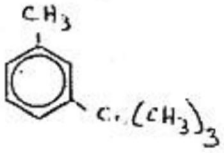


look for the "horseshoe" of delocalised electrons (somewhere around the rest of the ring, away from the sp^3 carbon atom) and the (+) charge somewhere on/near the horseshoe (NOT on the sp^3 carbon. A (+) charge on H or NO_2 negates [1]

(ii) $X^+ = NO_2^+$ [1]
(iii) $Z^+ = H^+$ (NOT H_3O^+) (penalise once only for absence of (+) signs) [1]

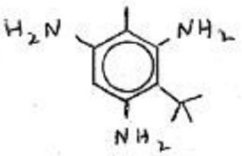
(iv) $2\,H_2SO_4 + HNO_3 \longrightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$ [2]
([1] for species, [1] for balancing. Allow [1] for: the acids $\longrightarrow NO_2^+ + HSO_4^-$ $(+H_2O)$)
5

(d) (i)



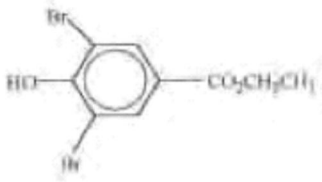
[1]

(ii)



Ignore alkyl groups – these can be "R" or even incorrect.
Allow NH_3^+ or NH_3Cl instead of one or more NH_2 groups [1]
2
Total: 10

Q21.

4	(a)		phenol, ester, arene/bezene ring	*any two*	(1) + (1)	**[2]**
	(b)	(i)	$Na^+ {}^- O\text{-}C_6H_4\text{-}CO_2C_2H_5$		(1)	
		(ii)	$Na^+ {}^- O\text{-}C_6H_4\text{-}CO_2{}^-Na^+$ ✓ C_2H_5OH ✓		(2)	
		(iii)			(1)	**[4]**

	(c)	(i)	acidity: G > E > F	(1)	
		(ii)	only G reacts/gives off CO_2 with Na_2CO_3	(1)	
			E and G both dissolve in NaOH(aq)	(1)	**[3]**
				Total: 9	

Q22.

7 **(a)** orange colour disappears/bromine is decolourised (NOT discoloured, *or* goes clear) **[1]**

(white) precipitate/solid/crystals is formed **[1]** **2**

(b) e.g. add neutral $FeCl_3$ (aq) – violet colour with phenol

or add universal indicator – red/orange colour with phenol

or add Na metal – fizzing/H_2 evolved with phenol

or add NaOH(aq) to the pure compound – phenol would dissolve

or add H^+ (aq) to the pure compound – phenylamine would dissolve

or add HNO_2 at room temperature – phenylamine would produce gaseous N_2.

or add HNO_2 at 5 °C, followed by an alkaline solution of phenol – phenylamine would produce a coloured (orange) dye **[1]** **1**

(c) IV $KMnO_4$ + heat **[1]**

V $HNO_3 + H_2SO_4$ **[1]** (both) conc^d and at 50 °C < T < 60 °C **[1]**

VI Sn + HCl (NOT $LiAlH_4$) **[1]** **4**

Q23.

4 (a) $HO\text{-}C_6H_4\text{-}NH_2 + 2AgBr + 2OH^- \rightarrow O{=}C_6H_4{=}O + H_2O + NH_3 + 2Ag + 2Br^-$ [1]
(*or* C_6H_7NO) (*or* $C_6H_4O_2$)

1

(b) rodinol should be **less basic** than NH_3 [1]

because the lone pair on N is delocalised over/overlaps with the aryl ring [1]

2

(c) **E** is $H_2N\text{-}C_6H_4\text{-}O^-\ Na^+$ *or* $H_2N\text{-}C_6H_4\text{-}ONa$ [1]

F is $HO\text{-}C_6H_4NH_3^+\ Cl$ *or* $HO\text{-}C_6H_4NH_3Cl$ [1]

G is $HO\text{-}C_6H_2Br_2\text{-}NH_2$ up to $HO\text{-}C_6Br_4\text{-}NH_2$ (ignore orientation) [1]

3

(d) (i) HNO_3(aq) or dil HNO_3 (**NOT** conc., and **NOT** + conc. H_2SO_4) [1]

(ii) reduction [1]

(iii) Sn + HCl(aq) [1]

3

(e) (i) phenol, amide [1] + [1]

(ii) CH_3COCl *or* $(CH_3CO)_2O$ [1]

3

total: 12

Q24.

4 **(a)** **(i)** light *or* heat [aq or $AlCl_3$ negates] (1)

(ii) NaOH/KOH/alkali/OH^- (1)
in alcohol/ethanol + heat [aq negates] (1)

(iii) $[-CH_2CH(C_6H_5)-]$ [C-C not needed, but C=C is wrong] (1)

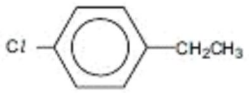
(iv) $CH_2=CHCN$ [C=C **is** needed here] (1) **[5]**

(b) **(i)** /OH^-(aq)/NaOH(aq)/aqueous alkali/ + heat [aq or solution or dil etc. needed] (1)

(ii) (pale) yellow ppt/crystals (**NOT** orange or orange-yellow) (1)

(iii) **C/D** is $C_6H_5CO_2Na$ ✓ **D/C** is CHI_3 ✓ (1) + (1) **[4]**

(c) **(i)**



(1)

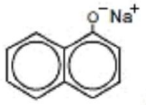
(ii) needs $AlCl_3$ or similar [light or aq negates] (1)

(iii) (hot) $KMnO_4$(aq) + OH^- or H^+ [NOT $Cr_2O_7^{2-}$] (1) **[3]**

[Total: 12]

Q25.

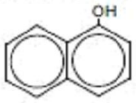
6 (a) (i)

C is 

allow ONa but no covalent O-Na bond [1]

(ii) amide, ester 2 x [1]

(iii) CO_2 *or* H_2CO_3 *or* Na_2CO_3 [1]
CH_3NH_2 *or* $CH_3NH_3^+Cl^-$ [1]



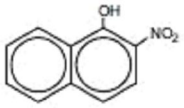
[1]

(iv) H_3O^+ and heat >80° *or* OH^-(aq) and heat >80° [1]
[7]

(b) (i) Br_2(aq) (or other suitable solvent) [1]

(ii) dilute/aqueous HNO_3 [1]
[2]

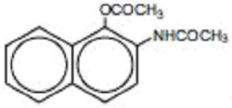
(c) (i)

D is 

[1]

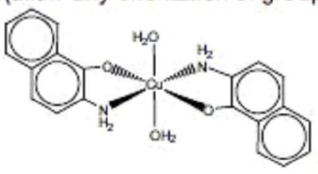
(ii) tin/Fe + HC*l* *NOT* LiA*l*H_4 [1]

(iii)



mark each side chain separately 2 x [1]
[4]

(d) (i) (allow any orientation of groups)



penalise missing H on NH_2 [1]

(ii) $[Cu(NH_3)_4]^{2+}$ *or* $[Cu(NH_3)_4(H_2O)_2]^{2+}$ *NOT* $[Cu(NH_3)_6]^{2+}$ [1]

(iii) ligand substitution/exchange [1]
[3]
[Total: max 15]

Q26.

5 **(a)** **G** is 4-nitromethylbenzene [1]
H is 4-nitrophenylethanoic acid [1]

(b) step II: Cl_2 + light *or* heat (T~100 °C) ($AlCl_3$ or aq. negates) [1]

step III: KCN (in ethanol) + heat (T~75 °C) (HCN negates) [1]

step V: Sn or Fe + HCl (+ heat) [1]

[Total: 5]

Q27.

4 **(a)** (cyclohexanol & phenol) hydrogen bonding to (solvent) water molecules [1]
due to OH group [1]
[2]

(b) phenoxide anion is more stable (than cyclohexoxide) / OH bond is weaker [1]
due to delocalisation of charge / lone pair over the ring [1]
[2]

(c)

reagent	product with cyclohexanol	product with phenol
Na(s)	RONa *or* RO^-Na^+	ArONa *or* ArO^-Na^+
NaOH(aq)	***no reaction***	ArONa *or* ArO^-Na^+
Br_2(aq)	***no reaction***	tribromophenol
I_2(aq) + OH^-(aq)	***no reaction***	***no reaction***
an excess of acidified $Cr_2O_7^{2-}$(aq)	cyclohexanone	***no reaction***

five correct products 5 × [1]
five correct "no reaction"s [2]
(4 correct = [1]; 3 correct = [0])
[7]

(d) *either* Br_2(aq): no reaction with cyclohexanol; decolourises *or* white ppt with phenol

or $Cr_2O_7^{2-}$ + H^+: turns from orange to green with cyclohexanol; no reaction with phenol

correct reagent chosen **and** the correct "no reaction" specified [1]
correct positive observation [1]
[2]

[Total: 13]

Q28.

5 (a)

compound	all carbon atoms can be coplanar	not all carbon atoms coplanar
A	✓	
B		✓
C	✓	
D	✓	
E	✓	

all 5 correct [3]
(4 correct: [2], 3 correct: [1]. <3 correct: [0])
[3]

(b) reaction **I**: Cl_2 + $AlCl_3$ / $FeCl_3$ / Fe / or bromides of Al or Fe [1]
reaction **II**: Cl_2 + heat / light / uv / hf [1]
[2]

(c) (i) **H** is $C_6H_5CH_2Cl$ [1]

(ii) reaction **III**: $KMnO_4$ + heat (+ OH^-) [1]
reaction **V**: NaOH in water + heat [1]
reaction **VI**: conc H_2SO_4 + heat [1]

(iii) reaction **III**: oxidation [1]
reaction **V**: hydrolysis *or* nucleophilic substitution [1]
[6]

[Total: 11]

Q29.

5 **(a)** **(i)** ester (1)

(ii) H is nitrobenzene – structure needed here (1)
J is phenyldiazonium chloride – structure needed here (1)

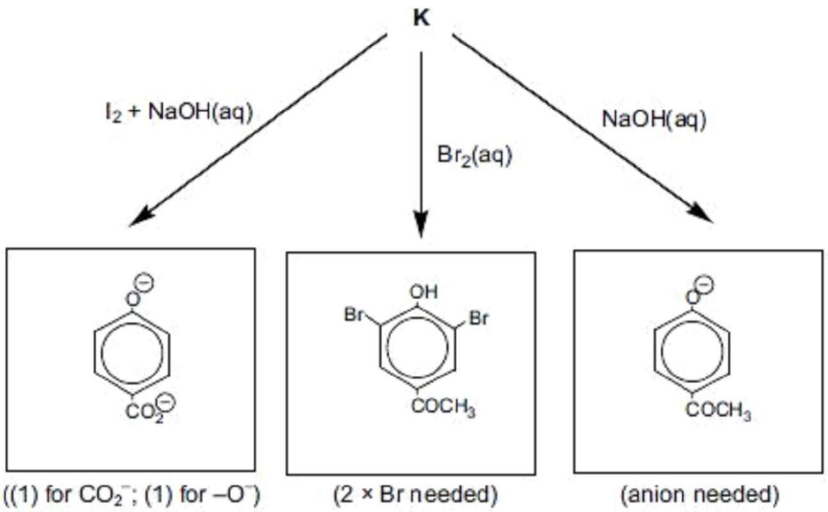
(iii) step 2 Sn/Zn + HC*l* / H_2 + named cat / $NaBH_4$ / $LiAlH_4$ / Na + ethanol (1)
step 3 HNO_2/$NaNO_2$ + HC*l* at T = 10°C or less (1)
step 4 heat/warm to T > 10°C (1)
step 5 CH_3COCl / $CH_3COCOCOCH_3$ (1) **[7]**

(b) **(i)** compounds that have the same molecular formula, but different structures (1)

(ii) phenol (NOT hydroxy) (1)
(methyl) ketone *or* carbonyl (1)

(iii) K is 4-ethanoylphenol, HO-C_6H_4-$COCH_3$ (must be 1,4- disubstituted isomer) (1)

(iv)



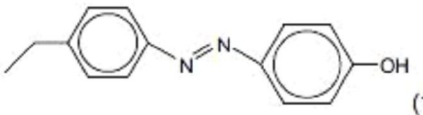
((1) for CO_2^-; (1) for $-O^-$) In any positions
(2 × Br needed)
(anion needed)

[4]
[8 max 7]

[Total: 14]

Q30.

4 reaction **I**: $C\underline{l}_2$ + light (1) (not aq)
reaction **II**: Br_2 + $AlBr_3$ *or* Fe *or* $FeBr_3$ (1) (not aq)
reaction **III**: NaOH, heat in ethanol (1) (allow aqueous EtOH)
reaction **IV**: HNO_3 + H_2SO_4 (1) conc and < 60°C (1) (2 marks)
reaction **V**: $KMnO_4$ + H^+/OH^- + heat (1)
reaction **VI**: Sn + HCl (1)
reaction **VII**: HNO_2 + HCl, < 10°C (1)

X is 

(1) allow $-N_2-$ and –ONa

[max 8]

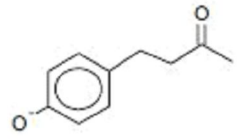
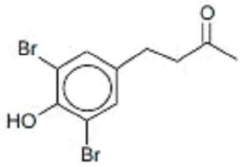
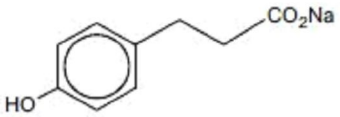
[Total: 8]

Q31.

5 **(a)** phenol [1]
ketone [1]

[2]

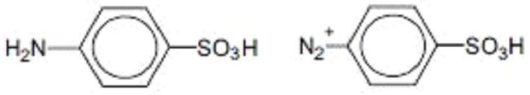
(b)

reagent	observation	structure of product	type of reaction
sodium metal	**effervescence /bubbles/fizzing**		*redox*
aqueous bromine	**decolourises** *or* **white ppt.**		*electrophilic substitution*
aqueous alkaline iodine	**yellow ppt.**		*oxidation*

[2]

[8]

(c) (i)



J **K**

[1] + [1]

(ii) step 1: $NaNO_2$ + HC*l* *or* HNO_2 [1]

at T < 10°C [1]

step 2: (add **K** to a solution of **G**) in aqueous NaOH [1]

[5]

(d)

$(CH_3CH_2CO_2H) \xrightarrow[\text{/}PCl_3 + \text{heat}]{SOCl_2/PCl_5} CH_3CH_2COCl \xrightarrow{\text{add to G (in NaOH(aq))}} \mathbf{L}$

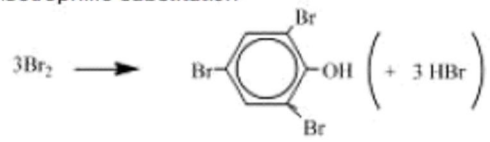
[1] [1] [1]

ecf from CH_3COOH **[3]**

[Total: 18]

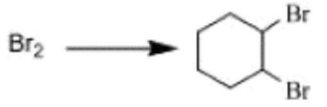
Q32.

5 **(a)** **(i)** Br_2(aq) [1]
electrophilic substitution [1]



[1]

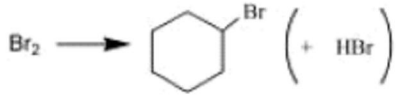
(ii) no special conditions [1]
electrophilic addition [1]



(allow bromohydrin *or* dibromide if Br_2(aq) has been used)

product [1]

(iii) light/UV *or* heat [1]
(free) radical substitution [1]

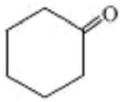


product [1]

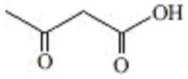
balanced equation in (i) (i.e. $3Br_2$ and 3HBr) [1]
balanced equation in (iii) (i.e. Br_2 and HBr) [1]

[11 max 10]

(b) (i)



C



D

CH_3CO_2H

E

3 correct structures (can be in any order) 3 × [1]

(ii) results of tests:

with 2,4–DNPH:	**C** and **D**	[1]
with $I_2 + OH^-$:	**D** only	[1]
with NaOH:	**D** and **E**	[1]

(N.B. letters may be different – must refer to the candidate's formulae)

[6]

[Total: 16]