A-Level Chemistry

Reactions of Benzene

Mark Scheme

Time available: 71 minutes
Marks available: 66 marks

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1.

(a) **M1** Acylation

Allow electrophilic substitution

Allow ethanoic anhydride for M2

1

M2 CH_3COCl OR Ethanoyl chloride

M3 dependent on M2

1

M3 $AlCl_3$ OR Aluminium chloride (mark could be awarded in space for M2)

Allow Dry/anhydrous for M3

Apply list principle to extra incorrect conditions

1

(b) **M1** Nucleophilic addition

1

M2 $NaBH_4$

Allow $LiAlH_4$ for M2

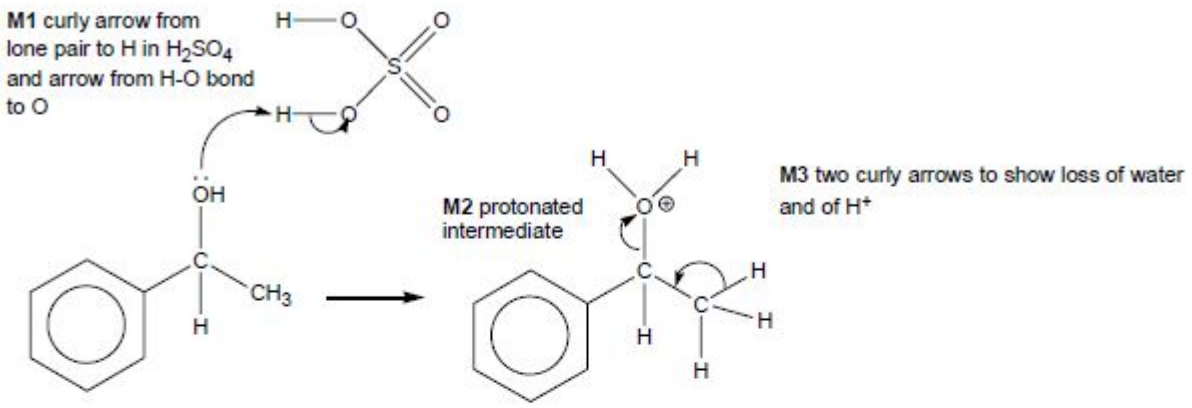
1

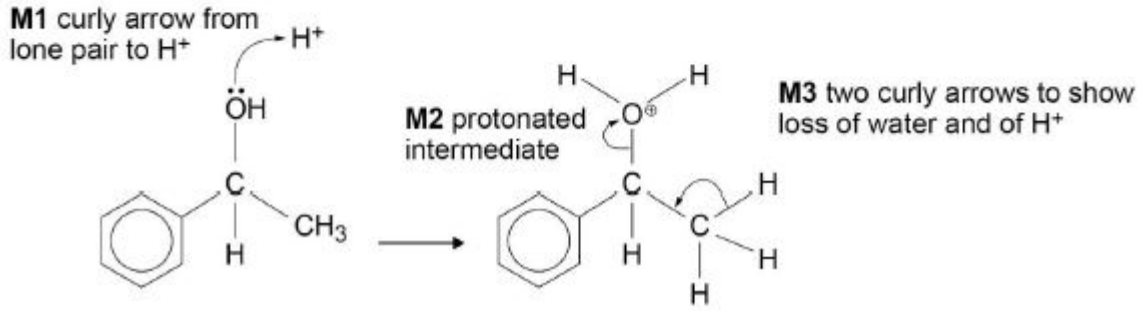
M3 1-phenyl ethan(-1-)ol

If H_2/Ni stated allow M2 and M3 but to score a matching M1 it would have to be Catalytic addition

1

(c)





*Penalise **M1** for mistakes on structure of H_2SO_4*

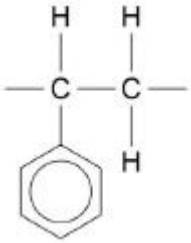
*Allow H^+ attacked in **M1***

*Allow **M3** as two steps*

Allow displayed formulae

3

(d)



Must show trailing bonds

Ignore brackets and any use of n

Allow C_6H_5 for phenyl group

1

[10]

2. (a) Electrophilic substitution both words needed

Allow minor spelling errors e.g. electrophillic or subsitution

Ignore nitration

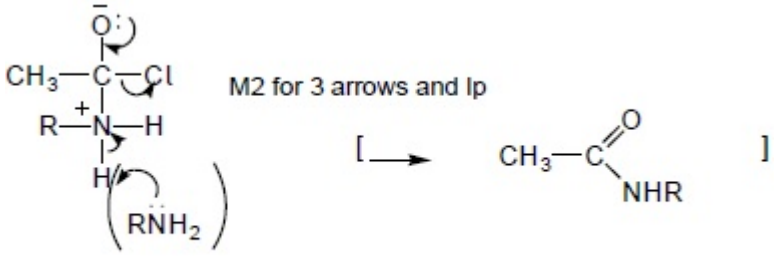
1

(b) + $3H_2$ ..... + $2H_2O$

Allow 6 [H]

1

(c)



***M1** for structure of ion including 2 charges (+ on N must be correct in both cases if drawn twice)*

***M2** for 3 arrows and lp on O - may be scored in two steps*

*Ignore use of RNH_2 to remove H^+ in **M2**, but penalise use of Cl^-*

2

(d) Corrosive **OR** forms strong acid/HCl (fumes) **OR** vulnerable to hydrolysis **OR** dangerous (to use)

*Allow anhydride is less corrosive **OR** does not form strong acid fumes **OR** less vulnerable to hydrolysis*

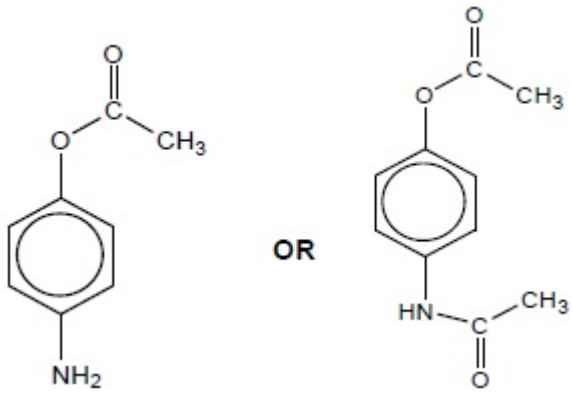
***OR** ethanoyl chloride is more expensive*

Allow reacts violently / extremely exothermic / extremely vigorous

Ignore toxic / harmful / hazardous

1

(e)



1

(f) + CH_3COONH_4 ..... + $2H_2O$

Allow CH_3COO^- / $CH_3CO_2^-$ and NH_4^+

Allow NH_4CH_3COO

1

(g) *Via moles*

M1 M_r paracetamol = 151(.0)

M1

M2 Amount paracetamol = 250×10^3 / 151.0 = 1655.6 mol
OR (250×10^3) / **M1**

(= amount hydroquinone used)

M2

M3 Mass hydroquinone = 1655.6 × 110.0 = 182119 g = 182 kg
OR correct answer to **M2** × 110.0 / 1000

M3

OR via mass
M1 *M_r paracetamol = 151(.0)*
So 110 g hydroquinone forms 151 g paracetamol
M2 *Mass hydroquinone needed 250 × 110 / 151.0*
OR *250 × 110 /* ***M1***
= 182 kg

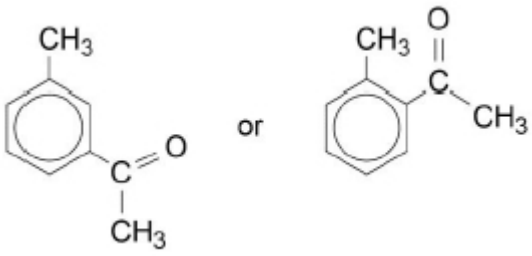
Min 2sf
If Mr values used wrong way round can score ***M2***

[10]

3. (a) $C_9H_{10}O$

1

(b)



1

Position (isomerism).

Allow Positional.

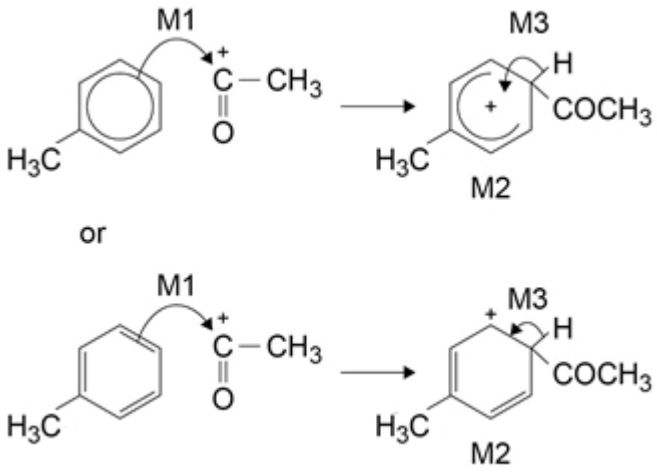
1

(c) Electrophilic substitution

1

$CH_3COCl + AlCl_3 \longrightarrow CH_3CO^+ + AlCl_4^-$

1



Mechanism 3 marks:

***M1** arrow from circle or within it to C of CH_3C^+O (+ must be on C of CH_3C^+O).*

1

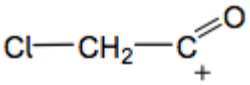
***M2** for Intermediate (**must** be 4-isomer)*
CH_3CO must be correctly positioned and bonded to gain M2
horseshoe must not extend beyond C2 to C6 but can be smaller
+ not too close to C1.

1

***M3** arrow into hexagon unless Kekule*
Loss of H^+ (allow from incorrect isomer)
Allow M3 arrow independent of M2 structure
Ignore base removing H in M3.
Allow Kekule structures (which must be correct).

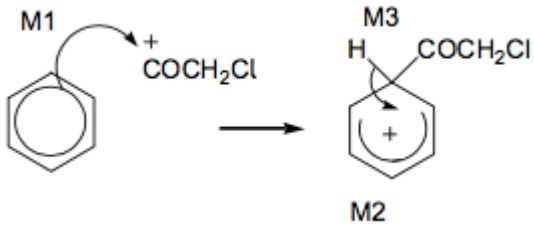
1

[8]

4. (a) (i) 

Allow $[ClCH_2CO]^+$

1

(ii) 

M1 for arrow from inside hexagon to C or + on C on correct electrophile

M2 for structure of intermediate

- *Horseshoe centred on C1;*
- *+ in intermediate not too close to C1 (allow on or "below" a line from C2 to C6)*

M3 for Arrow from bond to H into ring

- *Allow M3 arrow independent of M2 structure*
- *+ on H in intermediate loses M2 not M3*
- *Ignore Cl- removing H^+*

1
1
1

(b) Reagent

Water

(Aqueous) silver nitrate

NaOH followed by acidified silver nitrate

(Water +) named indicator

Named alcohol

Na_2CO_3 or $NaHCO_3$

Ammonia

1

P

No reaction

No reaction (or slow formation of ppt)

No reaction (or slow formation of ppt)

No colour change

NVC

NVC

No reaction

Do NOT award

No observation

1

Q

Steamy /misty/ white fumes

White precipitate (immediately formed)

White precipitate (immediately formed)

Indicator turns to correct acid colour

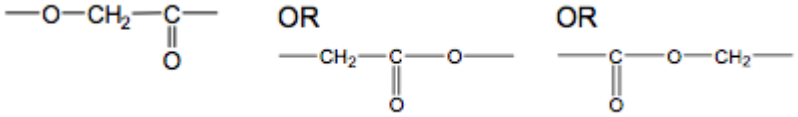
Fruity or sweet smell or misty fumes

Fizzing or effervescence (not just gas produced)

White smoke

1

(c) (i)



One unit only

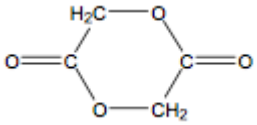
Must have trailing bonds

Ignore n and brackets

allow —O—CH_2—CO—

1

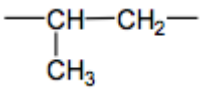
(i)



Allow CO for C=O

1

(d) (i)



One unit only

Must have trailing bonds

Ignore n and brackets

1

(ii) PGA sutures react/dissolve/break down/are biodegradable/ are hydrolysed / attacked by water or nucleophiles /no need to remove

OR Polypropene not biodegradeable/ not hydrolysed / not attacked by water/nucleophiles

1

(Ester links have) polar bonds

polypropene contains non-polar bonds

ignore intermolecular forces

1

[12]

5. (a) Electrophilic substitution

Both words needed

Ignore minor misspellings

1

(b) (i) Sn / HCl

OR H_2 / Ni **OR** H_2 / Pt **OR** Fe / HCl **OR** Zn / HCl **OR** $SnCl_2$ / HCl

Ignore conc or dil with HCl,

Allow (dil) H_2SO_4 but not conc H_2SO_4

Not allow HNO_3 or H^+

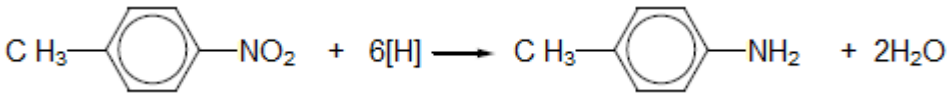
Ignore NaOH after Sn / HCl

Ignore catalyst

1

(ii) $CH_3C_6H_4NO_2 + 6[H] \rightarrow CH_3C_6H_4NH_2 + 2H_2O$

OR



Allow molecular formulae as structures given

$C_7H_7NO_2 + 6[H] \rightarrow C_7H_9N + 2H_2O$

Qu states use [H], so penalised $3H_2$

1

(iii) <u>making</u> dyes

OR <u>making</u> quaternary ammonium salts

OR <u>making</u> (cationic) surfactants

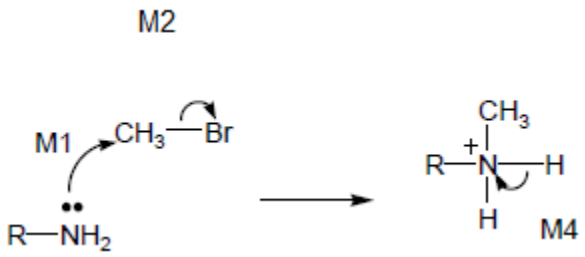
OR <u>making</u> hair conditioner

OR <u>making</u> fabric softener

OR <u>making</u> detergents

1

(c)



M3

NO Mark for name of mechanism

Allow SN1

M1 for lone pair on N and arrow to C or mid point of space between N and C

M2 for arrow from bond to Br

M3 for structure of protonated secondary amine

M4 for arrow from bond to N or + on N

For M4: ignore RNH_2 or NH_3 removing H^+ but penalise Br^-

4

(d) <u>lone or electron pair on N</u>

If no mention of lone pair CE = 0

If lone pair mentioned but not on N then lose M1 and mark on

M1

1

in **J** spread / delocalised into ring (or not delocalised in K)

Ignore negative inductive effect of benzene

*Allow interacts with **Π** cloud for M2*

M2

1

less available (for protonation or donation in **J**)

M3

OR

in **K** there is a positive inductive effect / electron releasing)

M2

more available (for protonation or donation in **K**)

M3

1

[11]

6. (a) (i) conc HNO_3

1

conc H_2SO_4

allow 1 for both acids if either conc missing

1

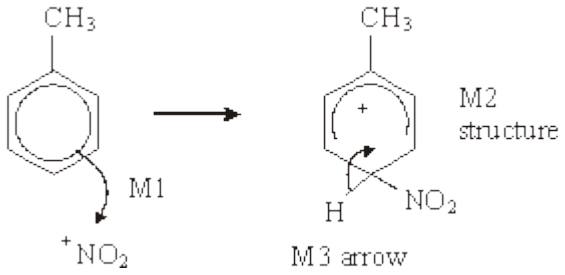
$HNO_3 + 2H_2SO_4 \rightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$

or $HNO_3 + H_2SO_4 \rightarrow NO_2^+ + H_2O + HSO_4^-$

1

(iii) electrophilic substitution CH_3

1



horseshoe must not extend beyond C2 to C6 but can be smaller
+ must not be too close to Cl

3

(b) Sn or Fe / HCl (conc or dil or neither)
or Ni / H_2 not $NaBH_4$ $LiAlH_4$

1

(c) (i) NH_3

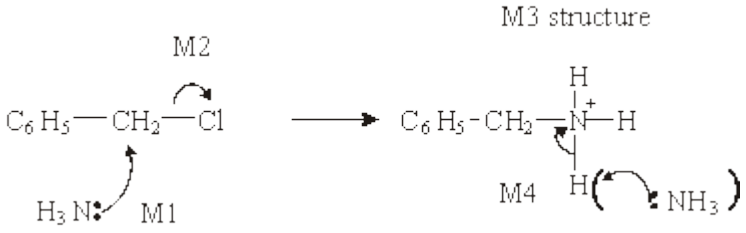
1

Use an excess of ammonia

1

(ii) nucleophilic substitution

1



4

[15]