Past-paper walk-through

Phenylamine and azo compounds ▪ 34.2

eXercise

Questions in this set

- 9701/41 N25 Q7 ▪ 12 marks
- 9701/42 N25 Q9 ▪ 14 marks

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 7

9701/41 N25 ▪ Q7 ▪ 12 marks

7 **(a)** State the relative acidities of bromoethanoic acid, $BrCH_2COOH$, chloroethanoic acid, $ClCH_2COOH$, ethanoic acid, CH_3COOH and ethanol, CH_3CH_2OH.

Explain your answer.

Question 7

most acidic

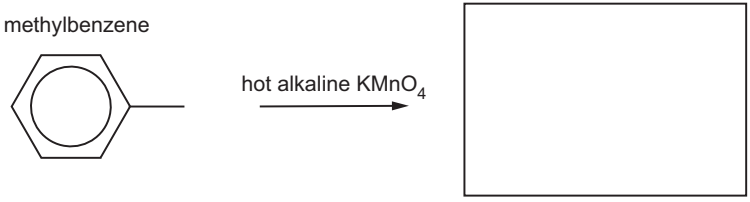
least acidic

Question 7

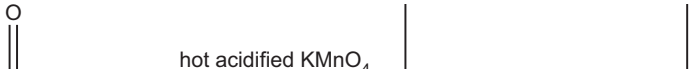
[4]

(b) Fig. 7.1 shows the reaction of methylbenzene and ethanedioic acid with $KMnO_4$.

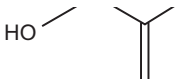
Predict the major carbon-containing product for each of these reactions.



Question 7



Question 7



Question 7

Fig. 7.1

[2]

(c) Polyamide **X** can be synthesised from ethanedioic acid and benzene-1,4-diamine.

benzene-1,4-diamine

(i) Draw the repeat unit of polyamide **X** in the box.

The new functional group formed should be shown displayed.

polyamide **X**

Question 7

polyamide **X**

Question 7

[2]

(ii) Benzene-1,4-diamine can be formed by reduction of 1,4-dinitrobenzene.

Complete the equation for this reduction.

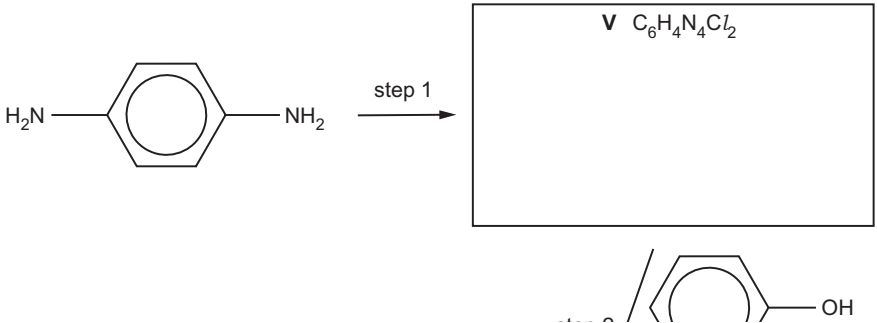
[H] represents one atom of hydrogen from a reducing agent.

Question 7

.....

[1]

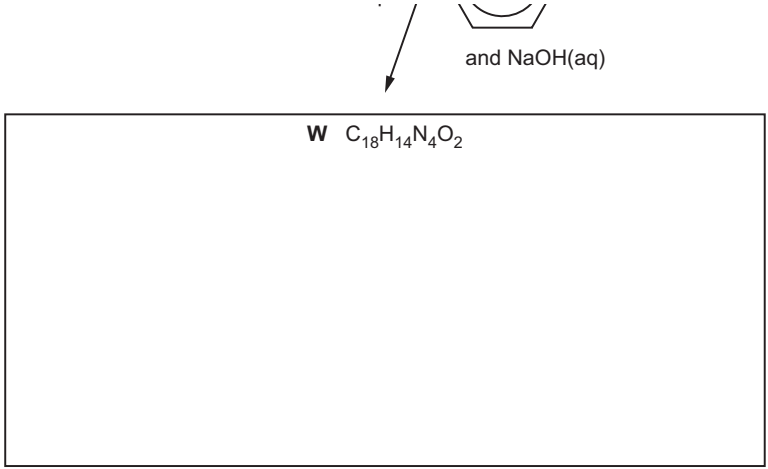
(d) Fig. 7.2 shows the two-step synthesis of the azo compound **W**.



Question 7

step 2 / \\ //

Question 7



Question 7

Question 7

Fig. 7.2

(i) Suggest structures for compounds **V** and **W** and draw them in the boxes in Fig. 7.2. [2]

(ii) Give the reagents and conditions for step 1.

Question 7

[Total: 12]

Solution 7

(a) Mark scheme

- M1: Cl CH2COOH
- BrCH2COOH CH3COOH CH3CH2OH
- most acidic
- least acidic
- M2: electron withdrawing groups / electronegative groups / negative inductive effect
- AND weakens O–H bond / more stable anion
- OR

Solution 7

- electron donating groups / positive inductive effect AND strengthens O-H bond / less stable anion **M3**
- M4:
- ▪
- chlorine is more electron-withdrawing / electronegative than bromine (related to XCH2COOH)
- ▪
- electron withdrawing of C=O / negative inductive effect of C=O (related to COOH)
- ▪

Solution 7

- positive inductive effect / electron donating of alkyl / ethyl / R group (related to ROH)
- any two [1], all three [2]
- 4

Solution 7

(b)

Mark scheme

- M1:
- M2: CO_2
- 2
- 9701/41
- October/November 2025

Solution 7

(c)(i)

Mark scheme

- M1: correct displayed amide bond with C=O, (C6H5)–N and (C–)C=O
- M2: rest of the structure correct with continuation bonds
- 2

(c)(ii)

Mark scheme

- 1

Solution 7

(d)(i)

Mark scheme

- M1:
- M2:
- 2
- 9701/41
- October/November 2025

Solution 7

(d)(ii)

Mark scheme

- HNO2 (and HCl) AND 10 °C
- OR
- NaNO2 AND HCl AND 10 °C
- 1

Question 9

9701/42 N25 ▪ Q9 ▪ 14 marks

9 Compound **X** is made from benzene by the route shown in Fig. 9.1.

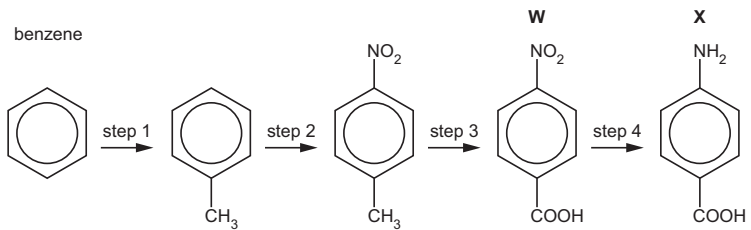


Fig. 9.1

(a) Describe the bonding in benzene, C_6H_6.

Question 9

Your answer should include:

- the hybridisation of the six carbon atoms
- the types of bond between the carbon atoms
- the orbitals that overlap to produce the bonds between the carbon atoms
- the type of bond between the carbon atoms and the hydrogen atoms
- the orbitals that overlap to produce the bonds between the carbon atoms and the hydrogen atoms.

Question 9

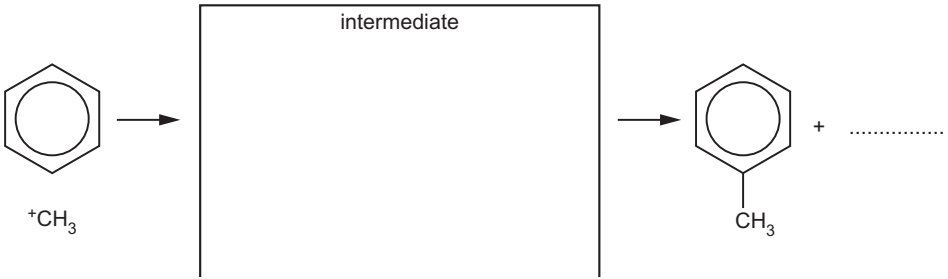
(b) Describe the reagents and conditions required for step 1 in Fig. 9.1.

Question 9

(c) In step 1 of Fig. 9.1 benzene reacts with $^{+}CH_3$.

Complete Fig. 9.2 to show the mechanism for this reaction, including:

- the movement of electron pairs using curly arrows
- the structure of the intermediate involved.



Question 9

Question 9

Fig. 9.2

[3]

(d) Describe the reagents and conditions required for step 2 of Fig. 9.1.

Question 9

(e) Identify the reagents required for step 3 of Fig. 9.1. Compound **W** is the product of this step.

Question 9

(f) Name compound **W**.

Question 9

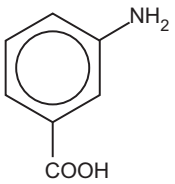
(g) The reagents commonly used for step 4 will **not** reduce the –COOH group.

Identify the reagents and conditions required for step 4 of Fig. 9.1.

Question 9

(h) Benzene can also be used as a starting material to make compound **Y**.

compound **Y**



Describe how the route described in Fig. 9.1 (repeated below) can be changed to give compound **Y** instead of compound **X**.

Explain your answer.

Question 9

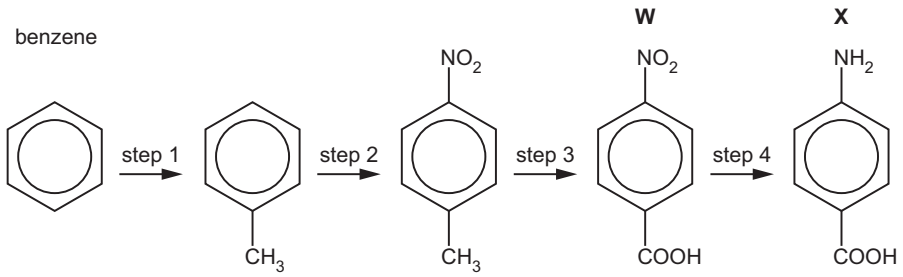


Fig. 9.1

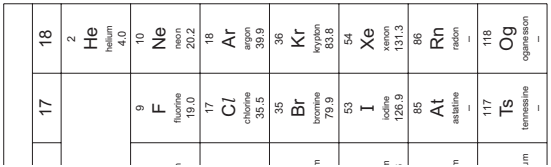
[Total: 14]

Important values, constants and standards

Question 9

Question 9

molar gas constant	$R = 8.31\,\text{J K}^{-1}\,\text{mol}^{-1}$
Faraday constant	$F = 9.65 \times 10^{4}\,\text{C mol}^{-1}$
Avogadro constant	$L = 6.02 \times 10^{23}\,\text{mol}^{-1}$
electronic charge	$e = -1.60 \times 10^{-19}\,\text{C}$
molar volume of gas	$V_m = 22.4\,\text{dm}^3\,\text{mol}^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0\,\text{dm}^3\,\text{mol}^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14}\,\text{mol}^2\,\text{dm}^{-6}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18\,\text{kJ kg}^{-1}\,\text{K}^{-1}$ ($4.18\,\text{J g}^{-1}\,\text{K}^{-1}$)



able of Elements

roup

			13	14	15	16
			5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxyger 16.0
			13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1
10	11	12				
28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se seleniu 79.0
46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te telluriu 127.6
78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po poloniu –
110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermoriu –

64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbiu 173.1
96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobeliu –

The Periodic T

G

1
H
hydrogen
1.0

Key

atomic number
atomic symbol
name
relative atomic mass

3	4	5	6	7	8	9
21	22	23	24	25	26	27
Sc	Ti	V	Cr	Mn	Fe	Co
scandium	titanium	vanadium	chromium	manganese	iron	cobalt
45.0	47.9	50.9	52.0	54.9	55.8	58.9
39	40	41	42	43	44	45
Y	Zr	Nb	Mo	Tc	Ru	Rh
yttrium	zirconium	niobium	molybdenum	technetium	ruthenium	rhodium
88.9	91.2	92.9	95.9	–	101.1	102.9
57–71	72	73	74	75	76	77
lanthanoids	Hf	Ta	W	Re	Os	Ir
	hafnium	tantalum	tungsten	rhenium	osmium	iridium
	178.5	180.9	183.8	186.2	190.2	192.2
89–103	104	105	106	107	108	109
actinoids	Rf	Db	Sg	Bh	Hs	Mt
	rutherfordium	dubnium	seaborgium	bohrium	hassium	meitnerium
	–	–	–	–	–	–

57	58	59	60	61	62	63
La	Ce	Pr	Nd	Pm	Sm	Eu
lanthanum	cerium	praseodymium	neodymium	promethium	samarium	europium
138.9	140.1	140.9	144.2	–	150.4	152.0
89	90	91	92	93	94	95
Ac	Th	Pa	U	Np	Pu	Am
actinium	thorium	protactinium	uranium	neptunium	plutonium	americium
–	232.0	231.0	238.0	–	–	–

1	2
3 Li lithium 6.9	4 Be beryllium 9.0
11 Na sodium 23.0	12 Mg magnesium 24.3
19 K potassium 39.1	20 Ca calcium 40.1
37 Rb rubidium 85.5	38 Sr strontium 87.6
55 Cs caesium 132.9	56 Ba barium 137.3
87 Fr francium –	88 Ra radium –

lanthanoids

actinoids

Solution 9

(a) Mark scheme

- ▪
- all C atoms are sp2 hybridised
- ▪
- bonds between C atoms are σ and π
- ▪
- C–C σ bonds are formed by overlap of sp2 hybrid orbitals
- ▪
- C–C π bonds are formed by overlap of p orbitals

Solution 9

- ▪
- bonds between C and H atoms are σ
- ▪
- C–H bonds are formed by overlap of sp2 hybrid orbitals and s orbitals
- Any two [1], any four [2], all six [3]
- 3
- 9701/42
- October/November 2025

Solution 9

(b)

Mark scheme

- CH3Cl and Al Cl 3/1

Solution 9

(c)

Mark scheme

- M1: curly arrow from within hexagon towards +C
- M2: intermediate, usual rules for horseshoe and + charge
- M3: curly arrow from C–H bond into ring AND H+ product
- 3

Solution 9

(d)

Mark scheme

- M1: HNO3 AND H2SO4
- M2: concentrated AND 25 °C T 60 °C
- 2

Solution 9

(e)

Mark scheme

- alkaline KMnO4
- 1

Solution 9

(f)

Mark scheme

- 4-nitrobenzoic acid
- 1

Solution 9

(g)

Mark scheme

- (hot) concentrated HCl and Sn
- 1

Solution 9

(h)

Mark scheme

- M1: perform step 3 before step 2 OR perform step 2 before step 1
- M2: COOH is 3-directing OR NO2 is 3-directing
- 2