Write your name here

Surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

International Advanced Level
Unit 5: Transition Metals and Organic Nitrogen Chemistry

Sample Assessment Materials for first teaching September 2018

Time: 1 hour 45 minutes

Paper Reference **WCH15/01**

You must have:
Data Booklet, scientific calculator, ruler

Total Marks

Instructions

- Use **black** ink or **black** ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*
- **Show all your working in calculations and include units where appropriate**.

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- In questions marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically showing how the points that you make are related or follow on from each other where appropriate.
- There is a Periodic Table on the back page of this paper.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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Pearson

SECTION A

Answer ALL the questions in this section.

You should aim to spend no more than 20 minutes on this section.

For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 This question is about complex ions.

(a) Which complex ion is square planar?

(1)

☒ **A** $[Cu(H_2O)_2(NH_3)_4]^{2+}$

☒ **B** $[CuCl_4]^{2-}$

☒ **C** $[Pt(NH_3)_2Cl_2]$

☒ **D** $[Ag(NH_3)_2]^{+}$

(b) Which copper complex ion is colourless?

(1)

☒ **A** $[CuCl_2]^{-}$

☒ **B** $[CuCl_4]^{2-}$

☒ **C** $[Cu(H_2O)_6]^{2+}$

☒ **D** $[Cu(H_2O)_2(NH_3)_4]^{2+}$

(c) Which complex ion includes a bond angle of 107°?

(1)

☒ **A** $[Cr(NH_3)_6]^{3+}$

☒ **B** $[CuCl_2]^{-}$

☒ **C** $[CuCl_4]^{2-}$

☒ **D** $[Cr(H_2O)_6]^{2+}$

(Total for Question 1 = 3 marks)

2 Which vanadium ion is yellow in aqueous solution?

- ☒ **A** VO^{2+}
- ☒ **B** VO_2^+
- ☒ **C** V^{3+}
- ☒ **D** V^{2+}

(Total for Question 2 = 1 mark)

3 Which reagent will be **most** effective at shifting the equilibrium towards the chromate(VI) ions?

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

- ☒ **A** hydrochloric acid
- ☒ **B** sulfuric acid
- ☒ **C** sodium hydroxide
- ☒ **D** water

(Total for Question 3 = 1 mark)

4 Which is **not** a bidentate ligand?

- ☒ **A** ethanedioate ion, $C_2O_4^{2-}$
- ☒ **B** ethanoate ion, CH_3COO^-
- ☒ **C** 1,2-diaminoethane, $NH_2CH_2CH_2NH_2$
- ☒ **D** 2-aminoethanoic acid, NH_2CH_2COOH

(Total for Question 4 = 1 mark)

5 A redox titration of iron(II) ions with potassium manganate(VII) is used to determine the amount of iron in iron tablets. The reaction is:

$$MnO_4^-(aq) + 8H^+(aq) + 5Fe^{2+}(aq) \rightarrow Mn^{2+}(aq) + 4H_2O(l) + 5Fe^{3+}(aq).$$

(a) Why is no indicator necessary in this redox titration?

(1)

☒ **A** an indicator would interfere with the redox reaction

☒ **B** no suitable indicator changes colour at the end point

☒ **C** the colour change of the iron(II) ions is sufficient

☒ **D** the colour change of the manganate(VII) ions is sufficient

(b) In one such titration, the following equipment was used.

Equipment	Uncertainty for each reading
100 cm^3 measuring cylinder	±1 cm^3
250.0 cm^3 volumetric flask	±0.15 cm^3
25.0 cm^3 pipette	±0.06 cm^3
50.00 cm^3 burette	±0.05 cm^3

Which piece of equipment has the **lowest** measurement uncertainty for this experiment?

(1)

☒ **A** the measuring cylinder to measure 100 cm^3 of sulfuric acid

☒ **B** the volumetric flask to make up the solution of the iron tablet

☒ **C** the pipette to measure out the iron(II) solution

☒ **D** the burette to add a titre volume of 25.00 cm^3

(c) A 25.0 cm^3 portion of an iron(II) tablet solution required 5.00×10^{-5} mol of manganate(VII) ions to react completely. What is the mass of iron, in grams, in the 25.0 cm^3?

(1)

☒ **A** 0.00058

☒ **B** 0.0028

☒ **C** 0.010

☒ **D** 0.014

(Total for Question 5 = 3 marks)

6 A hydrogen-oxygen fuel cell contains an alkaline electrolyte. The half-equation at the anode is:

$$H_2(g) + 2OH^-(aq) \rightarrow 2H_2O(l) + 2e^-$$

What is the half-equation at the cathode?

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

☒ **B** $O_2(g) + 2H^+(aq) + 2e^- \rightarrow H_2O_2(l)$

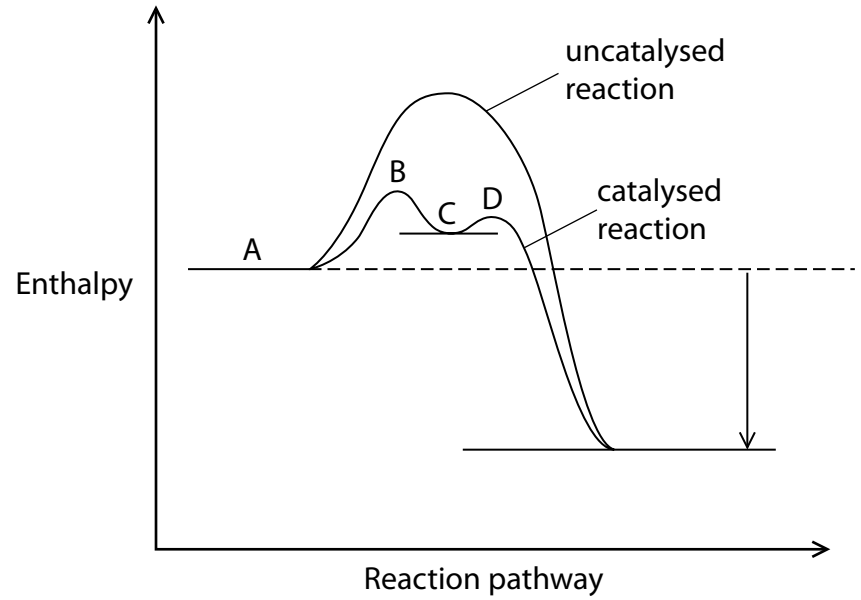
☒ **C** $\frac{1}{2}O_2(g) + 2H^+(aq) + 2e^- \rightarrow H_2O(l)$

☒ **D** $O_2(g) + H_2(g) + 2e^- \rightarrow 2OH^-(aq)$

(Total for Question 6 = 1 mark)

7 In homogeneous catalysis, the catalyst is in the same state as the reactants.

(a) The enthalpy profile diagram for a homogeneously catalysed reaction is



Which label indicates the intermediate species?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Iodide ions can be oxidised by peroxodisulfate(VI) ions in the reaction shown.

$$2I^-(aq) + S_2O_8^{2-}(aq) \rightarrow I_2(aq) + 2SO_4^{2-}(aq)$$

What property of iron(III) ions enables them to act as homogeneous catalysts for this reaction?

(1)

☒ **A** they can be oxidised and then reduced

☒ **B** they can gain and then lose electrons

☒ **C** they provide an effective surface for reaction to occur on

☒ **D** they can form complex ion intermediates with a lower activation energy

(Total for Question 7 = 2 marks)

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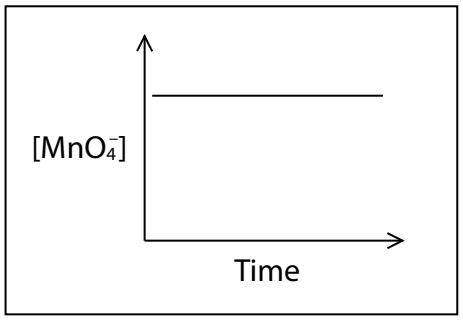
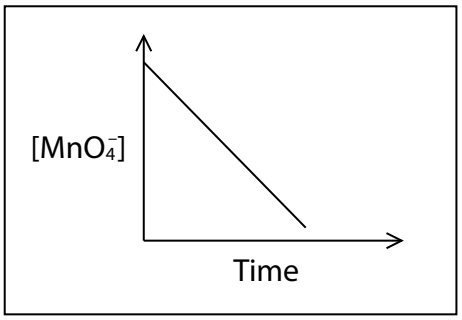
8 Which sketch shows the change in concentration of manganate(VII) ions with time in the reaction?

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

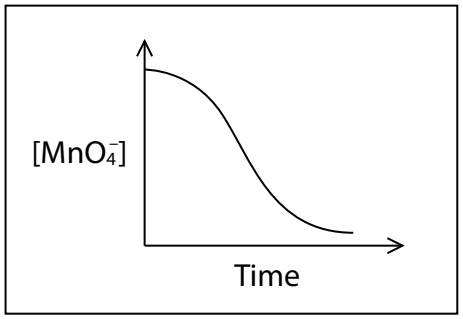
☒ **A**



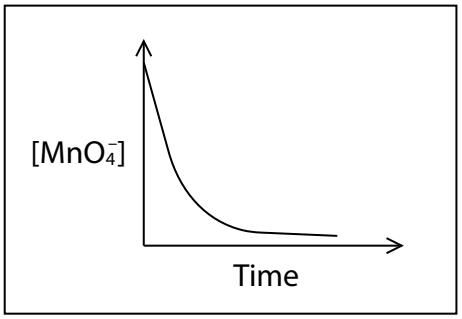
☒ **B**



☒ **C**



☒ **D**



(Total for Question 8 = 1 mark)

9 Identify the correct trend of **increasing** strength as a base.

☒ **A** $C_6H_5—NH_2 < H—NH_2 < CH_3—NH_2$

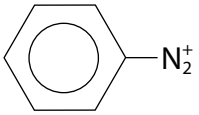
☒ **B** $C_6H_5—NH_2 < CH_3—NH_2 < H—NH_2$

☒ **C** $H—NH_2 < CH_3—NH_2 < C_6H_5—NH_2$

☒ **D** $H—NH_2 < C_6H_5—NH_2 < CH_3—NH_2$

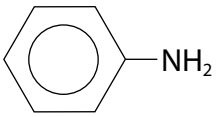
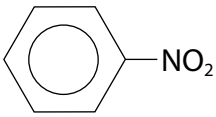
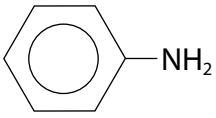
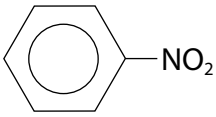
(Total for Question 9 = 1 mark)

10 Azo dyes are made from the benzenediazonium ion.



(a) Benzenediazonium ions can be made from:

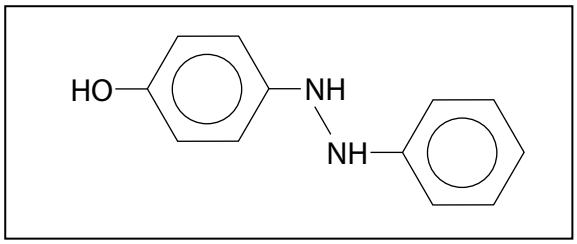
(1)

	Reagent 1	Reagent 2
☒ **A**	HNO_2	
☒ **B**	HNO_2	
☒ **C**	HNO_3	
☒ **D**	HNO_3	

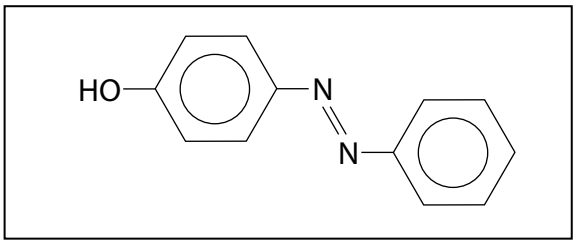
(b) The structure of the azo dye formed when benzenediazonium ions react with phenol is

(1)

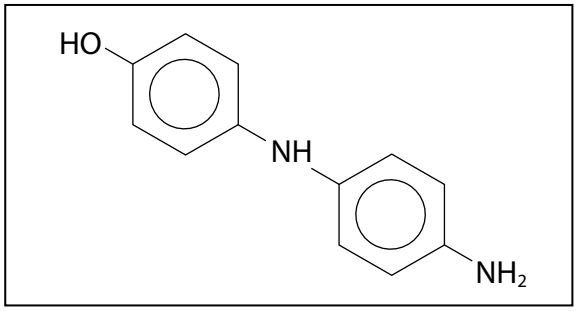
☒ **A**



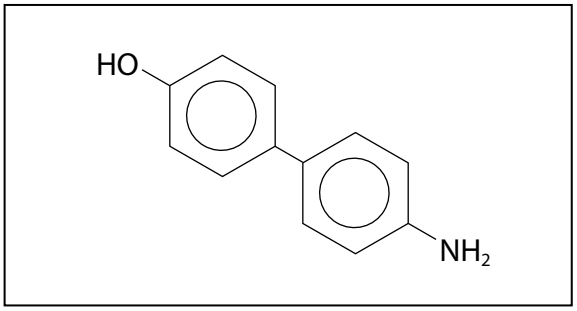
☒ **B**



☒ **C**



☒ **D**



(Total for Question 10 = 2 marks)

11 Which equation shows the two compounds that react to produce ethanamide, CH_3CONH_2, in a single step?

☒ **A** $CH_4 + HCONH_2 \rightarrow CH_3CONH_2 + H_2$

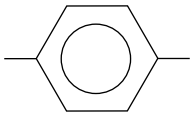
☒ **B** $CH_3COOH + NH_3 \rightarrow CH_3CONH_2 + H_2O$

☒ **C** $CH_3COCl + NH_3 \rightarrow CH_3CONH_2 + HCl$

☒ **D** $CH_3CHO + NH_3 \rightarrow CH_3CONH_2 + H_2$

(Total for Question 11 = 1 mark)

12 What is the number of peaks in a ^{13}C NMR spectrum of 1,4-dimethylbenzene?



☒ **A** 3

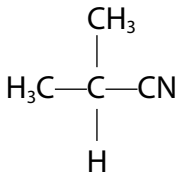
☒ **B** 4

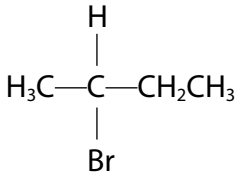
☒ **C** 7

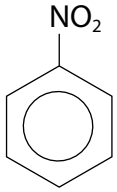
☒ **D** 8

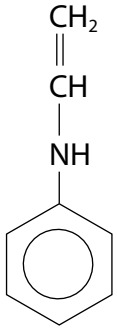
(Total for Question 12 = 1 mark)

13 Which combination of reactants will produce a primary aliphatic amine as the product?

☒ **A**  + Ni/H_2

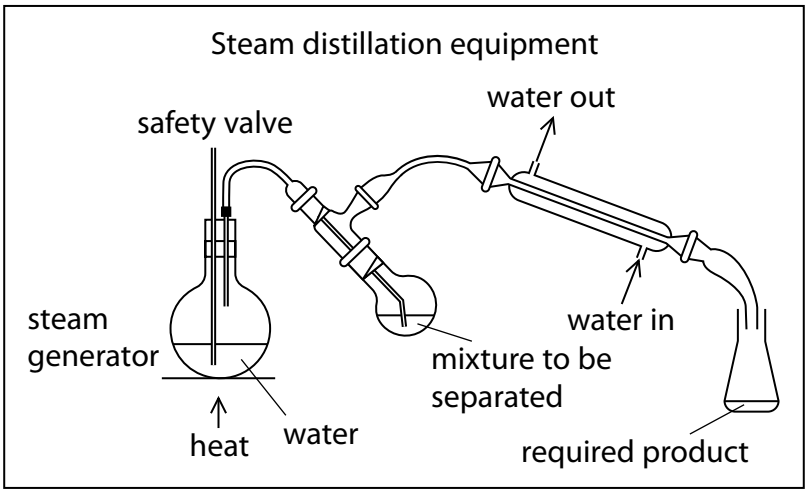
☒ **B**  + CH_3NH_2

☒ **C**  + Sn + conc HCl

☒ **D**  + Ni/H_2

(Total for Question 13 = 1 mark)

14 Steam distillation is a technique used during some organic preparations to separate the product from the reaction mixture.



What benefit is gained from the use of steam distillation compared to other methods of distillation?

- ☒ **A** a pure distillate is produced
- ☒ **B** high distillation temperatures are required
- ☒ **C** it works well for molecules miscible with water
- ☒ **D** it avoids the decomposition of the organic molecule when it distils

(Total for Question 14 = 1 mark)

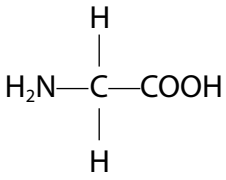
TOTAL FOR SECTION A = 20 MARKS

SECTION B

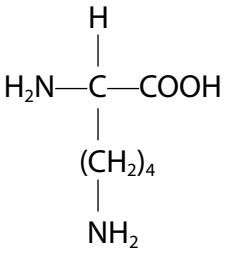
Answer ALL the questions.

Write your answers in the spaces provided.

15 Glycine and lysine are two naturally-occurring amino acids.



glycine



lysine

(a) Write the equation for the reaction of glycine with sodium hydroxide.
State symbols are not required.

(1)

(b) Calculate the volume, in cm^3, of 0.100 mol dm^{-3} hydrochloric acid required to completely react with 1.825 g of lysine.
[M_r of lysine = 146]

(2)

(c) Lysine exists as optically active enantiomers but glycine does not.

(i) Draw three-dimensional diagrams of the two optically active lysine enantiomers.

(2)

(ii) Describe how these optically active enantiomers could be distinguished. Practical details are not required.

(2)

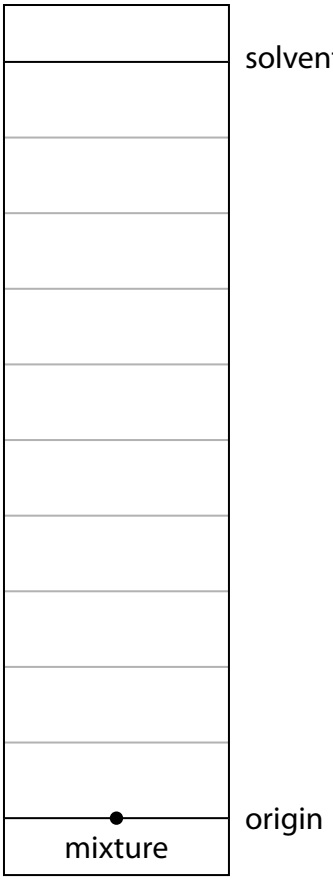
(iii) State why glycine does not exist as enantiomers.

(1)

(d) Chromatography can be used to separate a mixture of glycine and lysine.

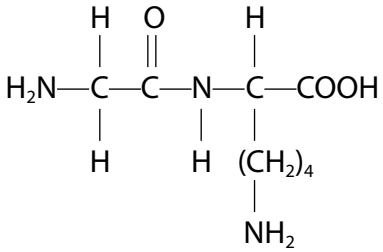
Draw spots to show the location of glycine and lysine on the chromatogram, given that their R_f values are 0.26 and 0.14 respectively.

(1)



(e) Naturally-occurring glycine and lysine can join together to form different dipeptides. Draw a different dipeptide of glycine and lysine.

(1)

Dipeptide 1	Dipeptide 2
	

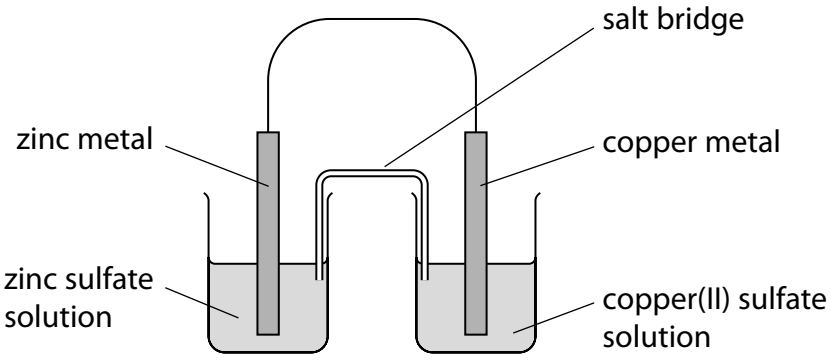
(Total for Question 15 = 10 marks)

16 Standard electrode potentials can be used to show whether or not a reaction is feasible.

(a) State the conditions required, in addition to 1 mol dm^{-3}, for obtaining standard electrode potentials.

(1)

(b) A Daniell cell is a combination of standard zinc and copper electrodes.



The standard electrode potentials measured against a standard hydrogen electrode are shown in the table.

Right-hand electrode system	$E^{\ominus}$/V
$Zn^{2+}(aq) \mid Zn(s)$	–0.76
$Cu^{2+}(aq) \mid Cu(s)$	+0.34

(i) Calculate the standard electrode potential of this cell.

(1)

(ii) Give **three** observations that would be made when current flows for several hours in the Daniell cell.

(2)

(c) Some standard reduction potentials are:

Electrode reaction	$E^{\ominus}$ / V
$Cu^{2+}(aq) + e^- \rightleftharpoons Cu^+(aq)$	+0.15
$Cu^+(aq) + e^- \rightleftharpoons Cu(s)$	+0.52
$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$	–0.44
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	+0.77

State and justify, in terms of $E^{\ominus}$ cell values, whether copper(I) ions and iron(II) ions will be disproportionate.
Include any equations for reactions which occur.

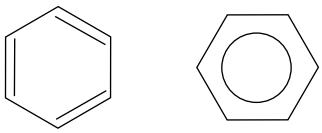
(3)

(d) State one reason why the feasibility determined from standard electrode potentials does not necessarily result in a reaction.

(1)

(Total for Question 16 = 8 marks)

17 Benzene can be represented by either a cyclic triene or with a delocalised ring of electrons.



*(a) Discuss the evidence, including one example from each of spectroscopy, thermochemistry and the type of reaction normally undergone, that supports the view that the better representation of benzene is with a delocalised ring of electrons.

(6)

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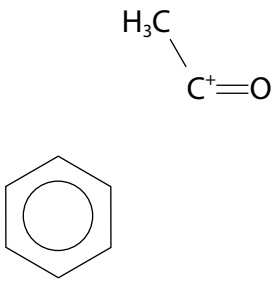
(b) Benzene can be converted into phenylethanone by a Friedel-Crafts acylation.

(i) Complete the diagram, including curly arrows, to show the mechanism for this reaction.

(4)



(ii) Write an equation to show how the species, CH_3CO^+, could be generated.

(1)

(c) Explain why phenol reacts with bromine more readily than benzene reacts with bromine.

(2)

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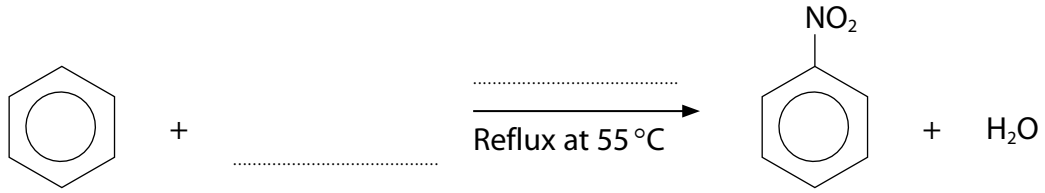
(d) Benzene can be converted into nitrobenzene.

(i) Complete the flow diagram showing this conversion.

(2)



(ii) Calculate the percentage yield if 0.642 g of nitrobenzene was made from 0.936 g of benzene.

Give your answer to an appropriate number of significant figures.

(3)

(Total for Question 17 = 18 marks)

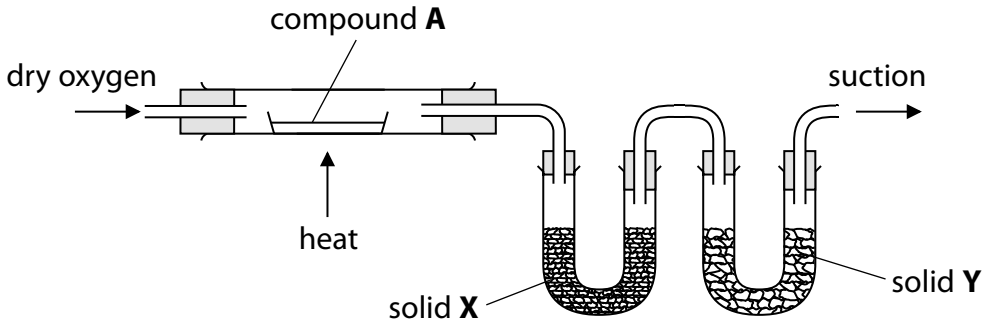
18 Butan-2-ol is a secondary alcohol with four carbon atoms.

(a) Devise a reaction scheme to form butan-2-ol from iodoethane, C_2H_5I, as the only organic compound.

Give reagents, conditions and equations for each of the steps.

(8)

(b) A 1.850 g sample of an organic substance, compound A, that is thought to be butan-2-ol is tested by combustion analysis using the apparatus shown.



absorbs moisture (water)
e.g. anhydrous calcium chloride

absorbs carbon dioxide
e.g. soda lime which is a mixture of calcium hydroxide and sodium hydroxide

(i) Calculate the mass increase of solid X and solid Y that would result if compound A is butan-2-ol.

(4)

(ii) Predict a substance which would give the same mass increase in solids X and Y from combustion analysis as butan-2-ol.
Give a reason for your prediction.

(2)

.....

.....

.....

.....

(Total for Question 18 = 14 marks)

TOTAL FOR SECTION B = 50 MARKS

SECTION C

Answer ALL the questions.

Write your answers in the spaces provided.

19

Brass is a metal alloy containing copper and zinc. The presence of zinc in the alloy makes brass less malleable than copper alone.

Prince's metal is one type of brass. It is used to make imitation gold because of its yellow colour.

The copper content of brass can be analysed by first reacting a known sample of the metal with concentrated nitric acid. The reaction of the copper is:

$$Cu + 4H^+ + 2NO_3^- \rightarrow Cu^{2+} + NO_2 + 2H_2O.$$

(a) Identify the element that is oxidised and the element that is reduced in the reaction shown. Include relevant oxidation numbers.

(2)

(b) Suggest one precaution when carrying out this reaction, other than the use of gloves, goggles and lab coats, clearly stating the hazard concerned.

(2)

(c) The copper ions are then reacted with excess potassium iodide.

$$2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$$

The iodine formed is analysed by titration with sodium thiosulfate.

$$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$$

A 5.000 g sample of Prince's metal was analysed.
After reaction with concentrated nitric acid, the sample was diluted to 250 cm^3 and then 10.0 cm^3 aliquots or portions were titrated with 0.100 mol dm^{-3} sodium thiosulfate solution.
The mean titre was 22.65 cm^3.

Calculate the percentage of copper, by mass, in this sample of Prince's metal to an appropriate number of significant figures.

(6)

(d) In aqueous solution, copper(II) and zinc ions react differently with sodium hydroxide solution.

Describe the observations when sodium hydroxide solution is added drop by drop (until in excess) to separate samples of these two ions.

Include relevant **ionic** equations with state symbols.

(6)

(e) Explain, in terms of electronic configurations, why copper is classified as a transition element but zinc is not.

(2)

(f) Explain, in terms of their structures, why brass is less malleable than pure copper.

(2)

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(Total for Question 19 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 90 MARKS

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The Periodic Table of Elements

1 (1)	2 (2)											3 (13)	4 (14)	5 (15)	6 (16)	7 (17)	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Key: relative atomic mass / **atomic symbol** / name / atomic (proton) number

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series