Centre No.						Paper Reference							Surname	Initial(s)
Candidate No.						6	C	H	0	5	/	1	Signature	

Paper Reference(s)

6CH05/1

Edexcel GCE

Chemistry

Advanced

Unit 5: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry (including synoptic assessment)

Sample Assessment Material

Time: 1 hour 40 minutes

Examiner's use only		

Team Leader's use only		

Question Number	Leave Blank
Section A	
Section B	
Section C	
Total	

Materials required for examination	Items included with question papers
Data Booklet	Nil

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initial(s) and signature.
Check that you have the correct question paper.
Answer ALL the questions. Write your answers in the spaces provided in this question paper.
Some questions must be answered with a cross in a box (☒). If you change your mind, put a line through the box (☒) and then mark your new answer with a cross (☒).
Do not use pencil. Use black or blue ink.

Information for Candidates

The marks for individual questions and the parts of questions are shown in round brackets: e.g. **(2)**.
There are 24 questions in this question paper. The total mark for this paper is 90.
There are 28 pages in this question paper. Any blank pages are indicated.
Candidates may use a calculator.

Advice to Candidates

Quality of written communication will be taken into account in the marking of your responses to Questions 20(d), 21(c)(i), 21(c)(ii), 22(b)(i), 22(b)(ii), 23(a), 23(c)(iii), 24(a)(ii), 24(c), 24(d)(i) and 24(d)(ii). These questions are indicated with an asterisk. Quality of written communication includes clarity of expression, the structure and presentation of ideas and grammar, punctuation and spelling.

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 25 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 (☒).

Each of the questions or incomplete statements in this section is followed by four suggested answers, A, B, C and D. Select the BEST answer in each case.

1. In a standard hydrogen electrode

☐ **A** the hydrogen gas is at one atmosphere pressure

☐ **B** a solution of 1 mol dm^{-3} sulfuric acid is used

☐ **C** a temperature of 273 K is maintained

☐ **D** a piece of shiny platinum foil is used

Q1

(Total 1 mark)

2. For a redox reaction to be thermodynamically feasible, E_{cell} must be

☐ **A** positive

☐ **B** negative

☐ **C** greater than +0.3 V

☐ **D** more negative than –0.3 V

Q2

(Total 1 mark)

Leave blank

3. The standard electrode potential for the electrode system based on the equation below is +1.51 V.

$$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l)$$

Which of the following statements about the electrode system is correct?

☒ **A** the electrode potential at pH 5 is +1.51 V.

☒ **B** $Mn^{2+}(aq)$ is acting as an oxidising agent.

☒ **C** changing the concentration of $Mn^{2+}(aq)$ would cause a change in the electrode potential.

☒ **D** the electrode used in this half-cell is made of manganese.

Q3

(Total 1 mark)

4. Which of the following is always proportional to E_{cell} for a chemical reaction?

☒ **A** ΔH_r

☒ **B** ΔS_{system}

☒ **C** $\Delta S_{surroundings}$

☒ **D** ΔS_{total}

Q4

(Total 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

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5. Methanol can be vigorously oxidised with an acidified solution containing dichromate(VI) ions, $Cr_2O_7^{2-}$, to form methanoic acid and chromic(III) ions.

(a) What are the oxidation numbers of **carbon** in methanol and methanoic acid?

		Methanol	Methanoic acid
☒	**A**	–1	+1
☒	**B**	–2	+2
☒	**C**	+1	–1
☒	**D**	+2	–2

(1)

(b) How many moles of methanol react with one mole of dichromate(VI) ion, $Cr_2O_7^{2-}$?

☒ **A** 1

☒ **B** ¾

☒ **C** 1½

☒ **D** 3

(1)

(Total 2 marks)

Q5

6. Which of the following will **not** act as a ligand in the formation of complexes?

☒ **A** $C_6H_5NH_2$

☒ **B** CH_3NH_2

☒ **C** NH_4^+

☒ **D** NH_3

(Total 1 mark)

Q6

Leave blank

7. Which of the following ground state electron configurations corresponds to an element most likely to form an oxide with catalytic properties?

☒ **A** $1s^2\ 2s^2$

☒ **B** $1s^2\ 2s^2\ 2p^6\ 3s^2$

☒ **C** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$

☒ **D** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^2$

Q7

(Total 1 mark)

8. **X**, **Y**, and **Z** are three different compounds from the list below. **X** and **Y** react together to form an ester. **X** and **Z** also react to give the same ester as **X** and **Y**, but less readily.

Compound **Y** could be

☒ **A** propanoyl chloride

☒ **B** propanoic acid

☒ **C** propan-1-ol

☒ **D** propanal

Q8

(Total 1 mark)

9. Which of the following isomers of $C_4H_{10}O$ has a chiral centre?

☒ **A** Butan-1-ol

☒ **B** Butan-2-ol

☒ **C** 2-methylpropan-1-ol

☒ **D** 2-methylpropan-2-ol

Q9

(Total 1 mark)

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10. When the colourless liquid chlorobenzene is shaken with bromine water, the chlorobenzene becomes a yellow orange colour. What is the interpretation of this?

☒ **A** an addition compound of chlorobenzene and bromine has formed.

☒ **B** the chlorine atom has been replaced by a bromine atom.

☒ **C** a hydrogen atom has been replaced by a bromine atom.

☒ **D** the bromine is more soluble in chlorobenzene than in water.

Q10

(Total 1 mark)

11. What class of organic compound has a characteristic smell and gives a solution in water with a pH of about 10?

☒ **A** arene

☒ **B** amine

☒ **C** aldehyde

☒ **D** carboxylic acid

Q11

(Total 1 mark)

12. Which chemical term best describes what happens, when butylamine is added to a solution of a copper(II) salt?

☒ **A** precipitation

☒ **B** redox

☒ **C** proton transfer

☒ **D** complex formation

Q12

(Total 1 mark)

Leave blank

13. The substance of formula $(OCH_2CH_2OOCC_6H_4COOCH_2CH_2OOCC_6H_4CO)_n$ is a

- ☒ **A** polyester
- ☒ **B** natural oil or fat
- ☒ **C** detergent
- ☒ **D** protein

Q13

(Total 1 mark)

14. The optical isomers of alanine, $CH_3CH(COOH)NH_2$

- ☒ **A** have different melting points
- ☒ **B** rotate the plane of plane polarised light in opposite directions
- ☒ **C** react at different rates with ethanoyl chloride, CH_3COCl
- ☒ **D** both occur naturally in protein molecules

Q14

(Total 1 mark)

15. The rate equation for the reaction between aqueous sodium hydroxide and 2-chloro-2-methylpropane is

Rate = k[2-chloro-2-methylpropane]

The first step in the mechanism of this substitution reaction is

- ☒ **A** nucleophilic attack by OH^- ions on the carbon atom in the C–Cl bond
- ☒ **B** electrophilic attack by OH^- ions on the carbon atom in the C–Cl bond
- ☒ **C** the breaking of the C–Cl bond to form a carbocation
- ☒ **D** the simultaneous making of a O–C bond as the C–Cl bond breaks

Q15

(Total 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

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16. When hydrogen cyanide, HCN, is added to ethanal, CH_3CHO, the resulting solution has no effect on the plane of polarisation of plane polarised light.

This is because

☒ **A** ethanal is not chiral

☒ **B** the product is not chiral

☒ **C** the intermediate is planar

☒ **D** the product is a racemic mixture

Q16

(Total 1 mark)

17. Two compounds may be similar in that they both have

A dative covalent bonds in their molecules

B at least one bond angle of 120° in each molecule

C non-polar molecules

D linear molecules

Select from **A**–**D**, the similarity between each of the compounds below.

(a) Benzene, C_6H_6 and cyclohexane, C_6H_{12}

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

(b) Hydrogen cyanide, HCN, and carbon dioxide, CO_2

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

Q17

(Total 2 marks)

Leave blank

18. This question is about the following organic compounds:

A Benzene, C_6H_6

B Glycine, NH_2CH_2COOH

C Propene, CH_3CHCH_2

D Propanone, CH_3COCH_3

Select, from **A–D**, the compound which would

(a) be a solid at room temperature

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

(b) give a salt by reaction with sodium hydroxide

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

Use this space for any rough working. Anything you write in this space will gain no credit.

Leave blank

(c) give a sulfonic acid by reaction with fuming sulfuric acid

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

(d) form a precipitate when reacted with 2,4-dinitrophenylhydrazine

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1) **Q18**

(Total 4 marks)

Leave blank

19. Select, from **A–D**, the type of interaction which best describes the bonding between

(a) adjacent polymer chains in $\text{-}[CH_2\text{–}CH_2]_n\text{-}$

☒ **A** dative covalent

☒ **B** London forces

☒ **C** ion-dipole

☒ **D** ionic

(1)

(b) copper ions and ammonia in $Cu(NH_3)_4^{2+}$

☒ **A** dative covalent

☒ **B** London forces

☒ **C** ion-dipole

☒ **D** ionic

(1) **Q19**

(Total 2 marks)

TOTAL FOR SECTION A: 25 MARKS

Use this space for any rough working. Anything you write in this space will gain no credit.

Leave blank

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

20. A firm claims that their iron tablets contain 10 mg of Fe^{2+} per tablet. A chemist wishes to check this by titration using potassium manganate(VII) and dilute sulfuric acid.

$$Fe^{2+}(aq) \rightleftharpoons Fe^{3+}(aq) + e^-$$

$$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l)$$

(a) Why is the acid necessary?

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.....

(1)

(b) How many moles of Fe^{2+} react with one mole of MnO_4^-?

.....

(1)

Leave blank

(c) Each tablet contains 10 mg of Fe^{2+}.

(i) How many moles of Fe^{2+} are in one tablet?

(1)

(ii) Use your answer to (i) to calculate the volume of 0.010 mol dm^{-3} potassium manganate(VII) solution that would be needed to react with one tablet.

(2)

(iii) Is this a suitable volume to verify the integrity of the firm's claim? How would you alter the experiment to obtain a more suitable volume?

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(1)

Leave blank

*(d) The recommended consumption of Fe^{2+} per day is 14 mg. The tolerable upper level of consumption of Fe^{2+} per day is 45 mg.

The "10 mg iron tablets" produced by a pharmaceutical company contain between 9 and 11 mg of Fe^{2+}.

Discuss whether or not this range of iron content is acceptable.

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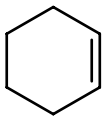
(2) **Q20**

(Total 8 marks)

Leave blank

21. (a) (i) Write the equation for the reaction between cyclohexene,  , and bromine.

(1)

(ii) Draw out the mechanism for this reaction.

(3)

(b) (i) Write the equation for the reaction between benzene,  , and bromine in the presence of a catalyst of anhydrous iron(III) bromide, $FeBr_3$.

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(1)

Leave blank

(ii) Draw out the mechanism for this reaction. Include an equation for the formation of the species that attacks the benzene ring.

(4)

(iii) Write an equation to show how the catalyst is regenerated.

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(1)

(c) Comment critically on:

*(i) the differences and similarities of the first steps involving the organic compounds in both reactions.

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(3)

Leave blank

*(ii) why the two intermediates formed in these first steps then react differently?

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(3)

(d) State the number of peaks in the proton nmr spectrum of the **product** of the reaction between cyclohexene and bromine.

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(1)

Q21

(Total 17 marks)

Leave blank

22. (a) (i) Give the electron configuration of:

Fe [Ar] .....

Fe^{2+} [Ar] .....

(1)

(ii) Draw the structure of the hexaaquairon(II) ion, $[Fe(H_2O)_6]^{2+}$, clearly showing its shape.

(1)

(iii) Give the equation for the complete reaction of hydroxide ions with a solution of hexaaquairon(II) ions.

(1)

(iv) State what you would **see** if the product mixture in (iii) is left to stand in air.

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(1)

Leave blank

(b) Consider the equation for the half reaction

$$Fe^{2+} + 2e^- \rightleftharpoons Fe \qquad E^{\ominus} = -0.44\ V$$

*(i) Define the term **standard electrode potential** with reference to this electrode.

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(3)

*(ii) Explain why the value of $E^{\ominus}$ suggests that the iron will react with an aqueous solution of an acid to give Fe^{2+} ions and hydrogen gas.

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(2)

(iii) State why $E^{\ominus}$ values cannot predict that a reaction will occur, only that it is possible.

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(1)

Q22

(Total 10 marks)

Leave blank

23. Many modern day fabric softeners are manufactured with the liquid enclosed in a water soluble capsule. The capsule is based on a polymer of ethenol.

*(a) Explain why poly(ethenol) is soluble in water.

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(2)

(b) Poly(ethenol) is made by hydrolysing poly(vinyl acetate), PVA, $[C_4H_6O_2]_n$.

(i) Draw the repeat unit of poly(ethenol)

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(1)

(ii) Write the formula of the monomer which polymerises to form poly(vinyl acetate), PVA (poly(ethenylethanoate)).

.....

(1)

(c) (i) 1,2-dibromocyclohexane reacts with ammonia to produce compound **A**, $C_6H_{14}N_2$. Give the structural formula of **A**.

(1)

Leave blank

(ii) Compound **A** reacts with hexanedioyl dichloride to produce a polymer.

Draw the structure of the repeating unit of this polymer.

(2)

*(iii) Suggest why this polymer cannot be made into **strong** fibres.

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(2)

(d) Classify the **two** polymerisation reactions.

Poly(ethene) .....

Fibre .....

(1)

Q23

(Total 10 marks)

TOTAL FOR SECTION B: 45 MARKS

SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

24. Read the passage below carefully and answer the questions which follow.

Stained glass and gemstones

Many medieval churches contain some very fine examples of stained glass coloured with transition metal compounds. Blue and green colours result from adding cobalt or copper oxides to molten glass. Copper oxide is added to colour the glass red, but it must be mixed with a strong reducing agent to give this colour. The red colour is so strong that it can appear black, and may need to be coated as a thin layer on top of colourless glass.

Like glass, many gemstones are based on silica and some on alumina. They are also coloured by transition metal compounds. A solid matrix of either silica, SiO_2, or alumina, Al_2O_3, has some of the silicon or aluminium replaced by a small quantity of a transition metal. Replacing about 5% of the aluminium ions in alumina with chromium(III) gives ruby, important in laser production. Replacement of aluminium ions by a mixture of iron(III) and titanium(III) gives sapphire. The metal coming in must have the same charge and about the same radius as the aluminium.

Based on 'Colour, A Chemical Overview' Chemistry Review volume 5, number 5, May 1996 written by Ken Kite

Leave blank

(a) The metals imparting colour to glass and gemstones mentioned in the passage are all transition elements.

(i) Define what is meant by a **transition element**.

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(1)

*(ii) Explain the processes which lead to hydrated transition metal ions being coloured.

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(3)

(b) (i) Give the formulae of the copper oxide which causes the red colour in glass.

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(1)

(ii) The production of red copper oxide is involved in a test for a functional group in organic chemistry. Name the reagent used in this test and the functional group it detects.

Reagent .....

Functional group .....

(2)

Leave blank

*(c) Why would the addition of iron(II) oxide, FeO, or osmium(III) oxide, Os_2O_3, **not** replace aluminium ions in alumina?

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(2)

*(d) (i) Starting with a chromium(III) compound, state how it could be converted into a chromium(VI) compound, a chromium(II) compound and a complex ion.

You should include equations and colour changes in your answer.

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(7)

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*(ii) Discuss the chemistry of the use of chromium salts in breathalysers. Explain why they are no longer used and describe the chemistry of one modern type of breathalyser.

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(4) Q24

(Total 20 marks)

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

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The Periodic Table of Elements

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

1.0
H
hydrogen
1

1	2											3	4	5	6	7	0 (8)
																	(18)
																	4.0 **He** helium 2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	
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											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 38	[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*** lathanum 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							

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