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GCE O Level Chemistry (7081)

January 2006

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CHEMISTRY 7081, MARK SCHEME

Paper 1

1. (a) (i) Na_2CO_3 **(1)**
(ii) $MgBr_2$ **(1)**
(iii) $(NH_4)_2SO_4$ **(1)**

(b) $2+ / Cu^{2+}$ **(1)**
$4+ / Sn^{4+}$ **(1)**

(c) Ag_2O **(1)**
$BiCl_3$ **(1)**

Total 7 marks

2. (a) methane / CH_4 **(1)**

(b) silver bromide / AgBr **(1)**

(c) sulphur dioxide / SO_2 / oxides of nitrogen **(1)**

(d) nitrogen / N_2 **OR** argon / Ar **(1)**

(e) bromine / Br_2 **(1)**

(f) carbon monoxide / CO **(1)**

Total 6 marks

3. (a) 137 **(1)**

(b) 19 **(1)**

(c) 10 **(1)**

(d) 25 **(1)**

(e) 7 **(1)**

(f) 4 **(1)**

Total 6 marks

4. (a) (i) correct balance 2,2,2,1 (or halved) **(1)**
(ii) correct balance 3,2,3,1,3 **(1)**

(b) (i) correct formulae **(1)**
balance **(1)**
(ii) correct formulae **(1)**
balance **(1)**

(c) $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$
correct ions **(1)**
balance + state symbols **(1)**

Total 8 marks

5. (a) nucleus with 4 protons and 5 neutrons **(1)**
electrons 2,2 **(1)**

(b) K^+ 2,8,8 **(1)**
F^- 2,8 **(1)**
correct charges **(1)**

(c) gas jar + delivery tube correctly arranged **OR** syringe **(1)**

(d) long tube + corks **(1)**
conc. ammonia (solution) **(1)**
conc. hydrochloric acid **(1)**
(penalise omission of 'conc' once only)
ring nearer HCl end **(1)**

Total 10 marks

6. (a) black **(1)**

(b) yellow / yellow-orange **(1)**

(c) red-brown / brown **(1)**

(d) purple **(1)**

(e) orange to green **(1)**

(f) brown / orange **(1)**

(g) green / yellow-green **(1)**

Total 7 marks

7. (a) use pH paper / universal indicator **(1)**
pH = 3 – 6

(b) gas turns limewater milky **(1)**
(1)

(c) $M_r = 97$ **(1)**

(d) $M_r\ CaCO_3 = 100$ **(1)**
100 g needs 194 g sulphamic acid **(1)**
therefore 1 g needs 1.94 g **(1)**
(allow 1 mark only for (d) if factor of 2 not used.)

Total 7 marks

8. (a) carbon-12 / ^{12}C **(1)**

(b) Avogadro **(1)**

(c) proton / atomic **(1)**

(d) groups **(1)**
periods **(1)**

(e) lose **(1)**
positive **(1)**

(f) transition / d-block **(1)**

Total 8 marks

9. (a) oxidation only **(1)**
Fe^{2+} loses an electron **(1)**

(b) both oxidation and reduction **(1)**
Mn^{4+} gains electrons therefore reduction **(1)**
Cl^- loses an electron therefore oxidation **(1)**

Total 5 marks

10. (a) CO-NH link shown and correctly bonded **(1)**

(b) $COO\text{-}CH_2CH_2\text{-}OOC$ link shown **(1)**
and correctly bonded **(1)**

(c) condensation **(1)**

(d) correct structure for poly(phenylethene) showing bonds **(1)**

(e) addition **(1)**

(f) oil supplies limited
burning produces CO_2 / toxic gases } any correct point
not biodegradable, etc. **(1)**

Total 7 marks

11. (a) five correct values i.e. 0.11, 0.37, 0.45, 0.22, 0.54 **(1)**

(b) plot **(1)**
straight line correctly positioned **(1)**

(c) mass of lead = 2.0 – 2.1 g **(1)**

(d) Pb = 3.5/207 O = 0.54/16 **(1)**
Pb : O = 0.0169 : 0.0338 **(1)**
Therefore 1 : 2 **(1)**
(Allow 3 marks for any clear, correct method)

(e) (i) $2PbO_2 \rightarrow 2PbO + O_2$ formulae **(1)**
balance **(1)**
(ii) relights a glowing splint **(1)**

Total 10 marks

12. (a) **conc.** sulphuric / phosphoric acid **or** Al_2O_3 **(1)**
heat / 170 – 200°C **or** high temp. / 300 –400°C **(1)**
(not 'heat' alone: second mark dependent on first)

(b) ethanoic acid / acetic acid **(1)**
CH_3COOH or displayed **(1)**

(c) ethyl ethanoate **(1)**
$CH_3COOC_2H_5$ or displayed **(1)**
ethanoic acid **(1)**
heat *(mark dependent on correct reactants)* **(1)**
conc. sulphuric acid (catalyst) **(1)**

Total 9 marks

13. (a) at the start / time zero / in first few seconds **(1)**
concentrations / amounts of A and B are greatest then **(1)**
greatest chance of collision **(1)**

(b) rates are equal **(1)**

(c) low temperature **(1)**
high pressure **(1)**
exothermic reaction favoured by low temperature **(1)**
decrease in moles / volume from left to right **(1)**
(correct condition must be selected before explanation mark can be awarded.)

Total 10 marks

PAPER TOTAL 100 MARKS

Paper 2

Section A

1. (a) solid: particles only vibrate **(1)**
liquid: particles move short distances before colliding / particles slide past each other **(1)**
solid: close together **(1)**
gas: far apart **(1)**

(b) heat to 65°C / boil off methanol **(1)**
condense vapour **(1)**
when temperature starts to rise / when all methanol boiled off **(1)**
propanol is left in the flask / raise temperature to boil off propanol **(1)**

(c) structure of propan-1-ol **(1)**
structure of propan-2-ol **(1)**

Total 10 marks

2. (a) bright light, etc. **(1)**
$H_2 + Cl_2 \rightarrow 2HCl$ **(1)**

(b) hydrogen chloride: molecules **(1)**
hydrochloric acid: $H^+(aq)$ and $Cl^-(aq)$ ions **(1)**
diagram: with shared pair of electrons **(1)**
other electrons correct **(dependent on the first mark)** **(1)**

(c) HCl in methylbenzene: no reaction with sodium carbonate **(1)**
hydrochloric acid: gas evolved / fizzes, etc. **(1)**
$H^+(aq)$ in aq. HCl cause acid behaviour **(1)**
equation (ionic or molecular) **(1)**

Total 10 marks

3. (a) variable valency
forms coloured ions / compounds } any 2
forms complexes **(2)**

(b) catalyst alters / speeds up the rate of reaction **(1)**
but is chemically unchanged itself **(1)**

(c) (i) Contact Process **(1)**
(ii) $2SO_2 + O_2 \rightarrow 2SO_3$ **(1)**
(iii) temperature range: 350 – 450°C **(1)**
pressure: 1 – 3 atm **(1)**
(iv) sulphur trioxide absorbed in conc. / 98% sulphuric acid **(1)**
then diluted with water **(1)**

Total 10 marks

4. (a) general formula
similar chemical properties
graded physical properties
same functional group
differ by CH_2
} any 2 **(2)**

(b) (i) tetrahedral arrangement shown in 3-D form **(1)**
(ii) C_8H_{18} **(1)**
(iii) octane is a larger molecule **(1)**
so intermolecular forces stronger **(1)**

(c) (i) replacement of a hydrogen atom by a halogen / chlorine atom **(1)**
$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$ **(1)**
(ii) correct formula of an alkene **(1)**
correctly balanced equation **(1)**

Total 10 marks

5. (a) add water to each metal (in a test tube) **(1)**
calcium will fizz (etc.) **(1)**
others do not react / slow reaction with magnesium **(1)**
add diluted HCl to Mg and Zn (in a test tube) **(1)**
Mg reacts / fizzes rapidly / lots of bubbles / gas evolved rapidly **(1)**
Zn fizzes (etc.) but slowly **(1)**
order is Ca > Mg > Zn **(1)**

(b) add **X** to salt solutions of metals **(1)**
X displaces metal / **X** does not displace metal **(1)**
X is more reactive than metal / less reactive than metal **(1)**

Total 10 marks

SECTION A: TOTAL 50 MARKS

Section B

6. (a) haematite / magnetite **(1)**
coal **(1)**
limestone **(1)**
air **(1)**

(4 marks)

coke burns to give heat / exothermic / temperature raised **(1)**
carbon / coke oxidised **(1)**
$C + O_2 \rightarrow CO_2$ **(1)**
limestone decomposes to form **calcium oxide** and **carbon dioxide** **(1)**
$CaCO_3 \rightarrow CaO + CO_2$ **(1)**
carbon dioxide is reduced to carbon monoxide **(1)**
$C + CO_2 \rightarrow 2CO$ **(1)**
Iron(III) oxide is reduced **(1)**
$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$ **or** $Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$ **(1)**
silicon dioxide is removed as slag or calcium silicate **(1)**
$CaO + SiO_2 \rightarrow CaSiO_3$ **or** $CaCO_3 + SiO_2 \rightarrow CaSiO_3 + CO_2$ **(1)**
slag floats on the surface and is tapped off **(1)**

Maximum 11 marks

(11 marks)

(b) (i) $TiCl_4 + 4Na \rightarrow Ti + 4NaCl$ **(1)**
(ii) Ti(IV) is reduced **(1)**
Na is oxidised **(1)**
Ti(IV) gains electrons and Na loses electrons **(1)**
(iii) to prevent reaction of Na / Ti with oxygen **(1)**
(iv) NaCl soluble / Ti insoluble **(1)**
filter off titanium **(1)**
(v) $M_r(TiCl_4) = 190$ **(1)**
190 kg $TiCl_4 \rightarrow$ 48 kg Ti (or worked in moles) **(1)**
4.8 kg Ti formed **(1)**

(10 marks)

Total 25 marks

7. (a) **isotopes**: atoms with same number of protons / same atomic number **(1)**
different numbers of neutrons / different mass number **(1)**
example: carbon-12 and carbon-14 **(1)**
allotropes: different forms of the same element in the same physical state **(1)**
example: diamond, graphite / rhombic, monoclinic sulphur **(1)**

(5 marks)

(b) **ionic bond***:* oppositely charged ions **(1)**
attract each other **(1)**
example: Na^+ and Cl^- **(1)**
covalent bond*:* a shared **pair** of electrons **(1)**
example: any correct molecule **(1)**

(5 marks)

(c) **metal**: delocalised electrons / sea of electrons **(1)**
free to move **(1)**
aqueous solution: movement of ions **(1)**
to oppositely charged electrode **(1)**
example: Na^+ to cathode and Cl^- to anode **(1)**

(5 marks)

(d) **atom** has equal number of protons and electrons / no charge **(1)**
example: Cl **(1)**
ion has more electrons than protons / negative charge / gained an electron **(1)**
example: Cl^- **(1)**

(4 marks)

(e) **mixture:** two (or more) substances interspersed but not chemically joined **(1)**
has properties of individual species / can be separated by physical means / variable composition **(1)**
example: air / crude oil / petroleum **(1)**
compound: two (or more) elements chemically joined / bonded **(1)**
properties different from individual species / must be separated by chemical means / constant composition **(1)**
example: any compound **(1)**

(6 marks)

Total 25 marks

8. (a) (i) name of ammonium salt **(1)**
name of alkali **(1)**
flask with delivery tube **(1)**
drying tube / tower **(1)**
with calcium oxide / silica gel **(1)**
gas collected by upward delivery / by syringe **(1)**
heat applied **(1)**
equation with correct formulae **(1)**
correctly balanced **(1)**

(ii) red litmus turns blue / pH paper turns blue (or blue/green)
or white fumes with conc. HCl **(1)**

(iii) e.g. less dense than air
very soluble in water
pungent gas
colourless gas
} any 2 **(2)**

(12 marks)

(b) (i) brown precipitate **(1)**
iron(III) hydroxide **or** formula **(1)**

(ii) blue precipitate **(1)**
copper(II) hydroxide **or** formula **(1)**
dissolves in excess to give deep blue solution **(1)**
$[Cu(H_2O)_2(NH_3)_4]^{2+}$ **or** name **(1)**

(6 marks)

(c) (i) 6.80 g of ammonia = 0.4 mol **(1)**
volume = 0.4 x 24000 cm^3 **(1)**
= 9600 cm^3 **or** 9.6 dm^3 **(1)**

(ii) Mr $(NH_4)_2SO_4$ = 132 **(1)**
0.4 mol ammonia $\rightarrow$ 0.2 mol $(NH_4)_2SO_4$ **(1)**
mass = 0.2 x 132 = 26.4 g **(1)**
(Accept any valid method for each calculation. Allow ecf)

(iii) fertiliser **(1)**

(7 marks)

Total 25 marks

9. (a) add to **anhydrous** copper sulphate / **anhydrous** cobalt chloride **(1)**
white to blue / blue to pink **(1)**
b.pt is 100°C **(1)**

(3 marks)

(b) blue solution **(1)**
brown gas **(1)**
nitrogen dioxide **(1)**

(3 marks)

(c) (i) $Cu^{2+}(aq) + 2e \rightarrow Cu(s)$ **(1)**

(ii) $2\ F \rightarrow 1\ mol\ Cu$ therefore $0.02\ F \rightarrow 0.01\ mol\ Cu$ **(1)**
mass = 0.01 x 63.5 **(1)**
mass = 0.635 g **(1)**

(iii) red / brown / copper deposit on cathode
colourless gas / bubbles at anode } any 2
blue colour fades **(2)**

(iv) no gas at anode
anode dissolves / becomes smaller } any 2
blue colour remains **(2)**

$Cu(s) - 2e \rightarrow Cu^{2+}(aq)$ **(1)**

(9 marks)

(d) (i) use of moles = mass / M_r **(1)**
moles H_2O = 0.72 / 18 = 0.04 mol **(1)**
moles CO_2 = 0.88 / 44 = 0.02 mol **(1)**
therefore $x = 1$ and $y = 2$ **(1)**
formula is $CuCO_3 .2Cu(OH)_2$ **(1)**
M_r = 318.5 **(1)**

(ii) turns black **(1)**
steam / condensation **(1)**

(iii) $2KOH + CO_2 \rightarrow K_2CO_3 + H_2O$
formulae **(1)**
balance **(1)**

(10 marks)

Total 25 marks

SECTION B TOTAL 50 MARKS

CHEMISTRY 7081, CHIEF EXAMINER'S REPORT

Paper 1

Question 1

(a) The formulae were often correct, but $(NH_3)_2SO_4$ and $Al_2(SO_4)_3$ were also written.

(b) and (c) Generally well done.

Question 2

Common wrong answers were 'nitrogen' in (a), 'silver chloride' or 'silver iodide' in (b) and 'carbon dioxide' in (d).

Question 3

This question was well done, the main error being '1' as the answer to (e).

Question 4

(a) A number of candidates did not attempt this part, but the others scored highly.

(b) This caused few problems apart from some incorrect formulae for zinc nitrate.

(c) This was answered well by many candidates but some included spectator ions; others did not write the state symbols.

Question 5

There were some very good answers to this question but some candidates ignored the instruction to draw labelled diagrams.

(a) Some answers had one shell with 4 electrons in it.

(b) Candidates were expected to draw all the electron shells and not just the outer ones. This question was not about a transfer of electrons: the diagrams needed to show the final arrangements in the ions. The charges were sometimes omitted.

(c) This was usually correct but some gas jars seemed to be corked at the top.

(d) Few candidates scored more than two marks. It was not generally realised that the cotton wool inserted at each end of the tube must be soaked in a **concentrated** solution. Many passed gas into the tube, and bungs were often missing.

Question 6

Some candidates ignored 'colours' in the introduction. The main errors were 'purple' in (c) and 'colourless' in (f). It should also be noted that the colour of the flame test for sodium should include 'yellow' (not just 'orange'). Similarly the colour of chlorine is 'green' or 'yellow-green' (not just 'yellow').

Question 7

Many scored five marks here, the other two being lost in part (a).

(a) There were answers suggesting the use of litmus paper, magnesium ribbon, calcium carbonate and conductivity. The correct test was to use pH paper or universal indicator.

(b) This was well done as usual.

(c) Most wrote '97' but '194' was quite common.

(d) This was often correct but some confused calcium sulphamate with calcium carbonate. The other more common error was to ignore the mole ratio in the equation.

Question 8

The answers to this question varied considerably but there were many good answers. The main problem was in part (a), where 'carbon' or 'hydrogen' were written rather than 'carbon-12' or '^{12}C'.

Question 9

This question was poorly done. There was much confusion about whether electrons were being lost or gained, often with contradictions between the two parts. Answers in terms of change in oxidation state were not accepted. Imprecise terminology also cost marks. It had to be clear that it is the Mn^{4+} ion that is gaining electrons (not 'manganese') and the chloride ion that is losing one (not 'chlorine'); a few candidates stated this correctly, but omitted to say which is oxidation and which is reduction.

Question 10

This question was also poorly done. Few candidates had any idea about polymerisation and those that did often ignored the instruction to show the arrangement of bonds in the polymer chain.

(a) '-CONH-' was quite common, but it does not show the bonding.

(b) It was rare to see even '-$COOCH_2CH_2OOC$-', and even rarer to see the bonds in the ester link.

(c) and (e) were well known, although some were in reverse order.

(d) This was better known than the condensation polymers, but there were many mistakes such as including a double bond, and mysteriously losing the C_6H_5.

(f) There were too many vague answers about pollution, polymers being dangerous and the need to save valuable resources (without making clear what they are).

Question 11

Many candidates scored full marks on this question but there were some common errors.

(a) This was usually correct.

(b) There were some very obviously misplotted points which should have alerted the candidates to possible errors. A straight line should be drawn with a ruler.

(c) There was some lack of precision in reading the mass of lead from the graph.

(d) Some candidates ignored the instruction to use the results from Experiment 5, and others used 32 instead of 16 as the denominator when calculating the number of moles. A significant minority decided to round '0.0169' up to '0.02' and '0.0338' down to '0.03' and then tried to convince the examiners that 0.02 : 0.03 is equal to 1 : 2.

(e) The equation was sometimes unbalanced despite correct formulae.

Question 12

This question tended to produce high scores from a number of well-prepared candidates, or close to zero; blank pages were fairly common.

(a) 'Concentrated' did not always accompany 'sulphuric acid'; the temperature for this reaction is usually about 170-200^{o}C but 'heat strongly' etc. was acceptable.

(b) This was often correct.

(c) The requirement for **concentrated** sulphuric acid as a catalyst was often omitted.

Question 13

There was confusion between reaction rate and position of equilibrium in some answers. As in the previous question, there were some excellent responses but also many blank spaces.

(a) Few appreciated that it is at the start of the reaction that the reaction is fastest, because of the high concentration of the reactants at that point.

(b) Some stated that the rates are 'constant' rather than being equal.

(c) Guesswork was common here but even when the correct combination was selected, the reasons were often wayward. Good candidates stated clearly that the exothermic reaction would be favoured by a low temperature and that a high pressure would favour the decrease in the number of moles of gas in the forward direction.

(d) This part was often answered successfully even by those who fared badly on the rest of the question. Most stated that the particles or molecules (not 'reactants') would have greater energy or speed but it was less common to see a reference to greater **frequency** of collisions.

Paper 2

Section A

Question 1

Knowledge of the states of matter was generally good, but there was some confusion over properties relating to motion and to distance.

Most candidates were able to go some way in describing the separation of methanol and propanol by distillation, however omission of important detail meant that only a small proportion obtained all four of the marks available.

Despite comments in previous reports, a worrying number of candidates still appears to believe that putting a bend in the carbon chain alters the structural formula of a compound.

Question 2

The photochemical reaction of hydrogen and chlorine was not well known and the supporting equation was frequently left unbalanced.

The majority of candidates knew that hydrochloric acid was an ionic compound but many omitted to state the ions present. A significant proportion of candidates drew diagrams showing the bonding in hydrochloric acid rather than in hydrogen chloride.

Comparisons of the properties of solutions of hydrogen chloride in water and in methylbenzene were sometimes confused and lacked important detail. Relatively few candidates scored well on the latter part of this question which is surprising, given the frequency with which this part of the syllabus has been asked in the past.

Question 3

The characteristics of transition metals and their compounds were well known.

Definitions of a catalyst were generally good. Unfortunately, a significant number of candidates erroneously suggested that a catalyst increases the rate of a reaction, but takes not part in it.

Knowledge of the industrial preparation of sulphuric acid was generally very good, however there was frequently some confusion over how sulphur trioxide is converted to sulphuric acid.

Question 4

Characteristics of an homologous series were generally well known, although there was some confusion over members having identical physical properties.

A large proportion of candidates made no attempt to show the tetrahedral shape of the methane molecule. Almost all candidates were able to give the molecular formula of octane, but relatively few were able to explain why the boiling point of octane is higher than that of methane. Answers which talked about octane being a bigger molecule attracted little credit, unless there was some reference to intermolecular forces of attraction.

The chlorination of methane was not well known and supporting equations were frequently incorrect. Most candidates were able to give an example of an addition reaction involving an alkene.

Question 5

This question was generally badly done, with candidates frequently obtaining no more than a few of the ten marks available.

The reactivity of calcium relative to magnesium and zinc should have been established by reacting the metals with water. Answers relating to the addition of dilute acid to metals frequently failed to take into account the high reactivity of calcium.

Descriptions of displacement reactions frequently lacked important detail.

Section B

Question 6

The reduction of iron ore in the blast furnace was frequently very well known and understood. Some confusion arose over the raw materials used: candidates who identified oxygen instead of air, calcium carbonate instead of limestone, and carbon instead of coke, lost marks.

The majority of candidates were able to offer a sensible equation for the displacement of titanium from titanium chloride, but far fewer were able to identify the species oxidised and reduced with suitable reasons. Relatively few candidates were able to explain the need for an inert atmosphere during the reaction.

Many of the candidates were able to explain how titanium and sodium chloride can be separated by mixing in water and filtration. Calculations of the mass of titanium obtained from the given mass of titanium(IV) chloride were often very well done.

Question 7

The differences between isotopes and allotropes were generally well known, however there was some confusion between isotopes and isomers. Many candidates failed to state that allotropes are different forms of the same element <u>in the same state</u>.

Ionic and covalent bonds were generally well understood, although a significant number of candidates failed to provide suitable examples of one or the other.

Conductivity in metals and solutions of salts was generally not well known. There was significant confusion between electrons and ions, and the mobility of these species frequently went unmentioned.

A significant proportion of candidates failed to read this question correctly and, as a result, answered this question in general terms about ions rather than the anions formed by non-metals.

The differences between mixtures and compounds were well known and most candidates were able to provide suitable examples of each.

Question 8

Most candidates were able to identify the reagents needed to make ammonia, the test to identify it, and its physical properties. Labelled diagrams were, however, frequently below an acceptable standard. Candidates are not expected to be able to provide perfect diagrams of apparatus, but they are expected to be able to draw recognisable versions of common apparatus.

The reactions of iron(II) ions and copper(II) ions with ammonia solution were reasonably well known, although there was some confusion over the precipitation of light blue copper(II) hydroxide and the subsequent darker blue solution formed by an excess of the reagent.

The majority of candidates were able to carry out calculations to find the volume of ammonia and the mass of ammonium sulphate. Almost all candidates knew that ammonium sulphate is an important fertiliser.

Question 9

This question proved to be the least popular, perhaps due to the unusual formulae given in part (d). However, candidates who attempted this question often produced answers of good quality.

Tests to show the presence and purity of water were well known as was the gas produced when copper reacts with concentrated nitric acid.

Most candidates were able to give meaningful answers about the electrolysis of copper(II) sulphate, although replacing the inert anode by a copper anode confused some candidates.

Many candidates appeared confused by the formula of the copper ore, however those who worked methodically through the question found that it was not as difficult as it appeared and often obtained high marks.

CHEMISTRY 7081, GRADE BOUNDARIES

Grade	A	B	C	D	E
Lowest mark for award of grade	69	56	43	38	25

Note: Grade boundaries may vary from year to year and from subject to subject, depending on the demands of the question paper