SYDNEY GRAMMAR SCHOOL

CRIB
Class

Student Number

2004
HIGHER SCHOOL CERTIFICATE TRIAL EXAMINATION

Chemistry
Section I Part A
ANSWER SHEET

General Instructions

- Write your class and candidate number in the space provided.
- Attempt all questions 1 – 15
- Use a blue or black pen
- Select the alternative A, B, C, or D that best answers the question.
- Fill in the response circle completely.

% correct

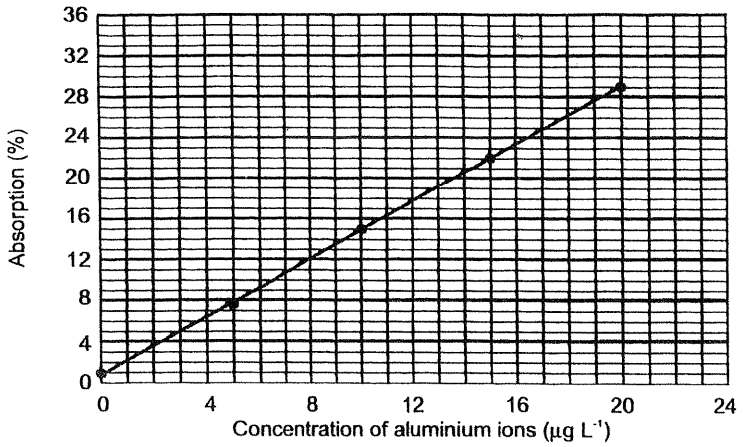
1.	A	**B**	C	D	72
2.	A	**B**	C	D	94
3.	A	B	**C**	D	97
4.	A	**B**	C	D	74
5.	A	**B**	C	D	57 *
6.	**A**	B	C	D	79
7.	A	B	**C**	D	54 *
8.	A	B	C	**D**	98
9.		B	C	**D**	
10.	A	B	C	**D**	78
11.	A	B	C	**D**	67
12.	A	**B**	C	D	
13.	A	B	C	**D**	69
14.	A	B	**C**	D	69
15.	A	B	**C**	D	74

PART B

Marks

Question 16 (2 marks)

Atomic absorption spectroscopy (AAS) can be used as an analytical tool for finding the concentration of elements in the ppm range. The graph below shows the relationship of absorption against concentration of aluminium ions. 2



Use this graph to determine the Al^{3+} concentration in ppm for a sample which registered an absorption of 10%.

Marks

16 Al^{3+} conc^{n} 6·5 µg L^{-1} 1

or 6.5×10^{-3} ppm 1

If this Al^{3+} conc^{n} were misread from the graph, but logical value in ppm ——> 1 mark.

N.B Boys often wrote $[Al^{3+}]$ for the concentration of Al^{3+}.

Question 17 (6 marks)

The equation $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ represents the synthesis of ammonia from its component gases and is known as the Haber process.

(a) Describe the geo-political conditions under which Haber developed the industrial synthesis of ammonia and evaluate its significance at this time in world history. 3

17 (a) Just prior to WW I Germany realised it was losing its access to natural fertilisers eg saltpetre, guano. Then Allies' naval blockade prevented importation of saltpetre from S America & so Germany needed to develop production of ammonia → home production of fertilisers and explosives

As the Haber process → NH_3 → prolonged WW I as Germans had synthetic fertilisers for their food production + NH_3 used in making explosives.

	Marks
Good description	3
Reasonable description	2
V. brief description	1
Wrong world war (eg WW II)	−1
'importing NH_3, rather than nitrogen compounds'	−1

17 (b) Explain why the Haber process is based on a delicate balancing act involving reaction energy, reaction rate and equilibrium. 3

17(b) $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)} + heat$

Forward reaction is exothermic

∴ T↑ → rate of reaction ↑, but will decrease yield of NH_3 (Le Chatelier's principle)

Catalyst → lower Ea → equilibrium reached faster, reasonable reaction rate.

(pressure) P↑ favours NH_3 yield (Le Chatelier's principle)

Removal of NH_3 also 'pulls' reaction to rhs (again Le Chatelier)

Marks

Logical discussion, including T, catalyst, P or removal of NH_3 and idea of compromise → 3 marks

Reasonable discussion.
- T↑ and catalyst
or temp and removal of NH_3
+ some idea of compromise → 2 marks

Some points describing the Haber process 1 mark.

Marks

Question 18 (5 marks)

Atomic absorption spectroscopy (AAS) is an extremely useful tool in the detection of metal ion concentrations.

(a) Explain why AAS is of little use in identifying unknown substances. 3

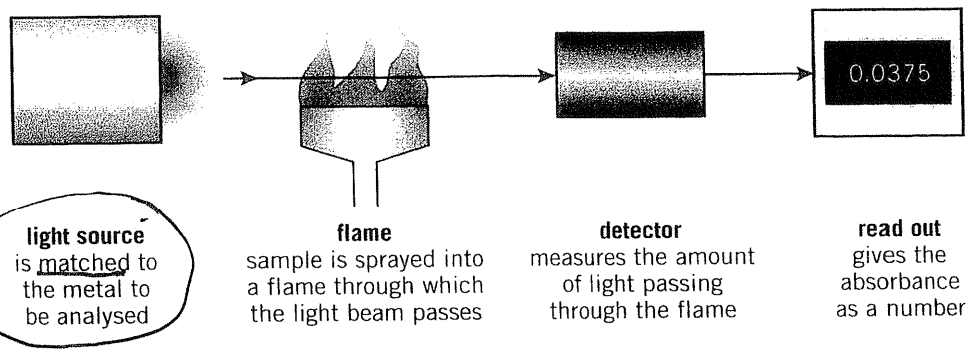


Figure 11.5
A diagrammatic representation of an atomic absorption spectrometer.

18 (a)

Atoms absorb & emit characteristic light frequencies
AAS [lamp (light source) emits light of specific* frequency of (metallic) element under test.
If sample does not contain the same element as in the AAS light source, then it is very unlikely that light will be absorbed in the AAS detector and the 'read out' to be meaningful.
∴ AAS can't be used for an unknown substance.
little use in identifying non-metallic compounds.

Marks	
3	Coherent explanation
2	Reasonable explanation
1	Some background on AAS

18 (b) Explain how AAS has had a major impact on the scientific understanding of the effects of trace elements. 2

.....

18 (b).

AAS may be used to detect cations in very low concns – ppm to ppb.

∴ This technique can measure trace elements, eg Co, Mn beneficial to crops + animals in very low concns.

Marks – must mention detection at very low concn – ppm or ppb 1

Give an example of the use of AAS measuring a trace (of Hg accepted) metal by name. 1

Question 19 (6 marks)

The fermentation of glucose is a chemical process which has been known to humans for at least 5 thousand years.

(a) Write a chemical equation to represent the fermentation of glucose. 2

$C_6H_{12}O_6(aq) \longrightarrow 2C_2H_5OH(aq) + 2CO_2(g)$

Equation must include correct states for 2 marks

(Balanced eqtn, but incorrect states: 1 mark)

(b) Under what physical conditions is fermentation optimised? 1

(b) Anaerobic or low O_2

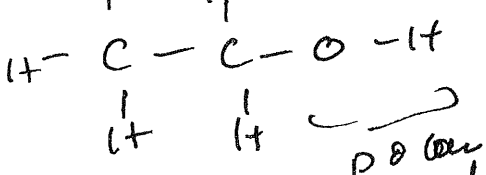
Temp. – body temp or 37 °C } both needed for 1 mark.

or even 'room temp'

'Moderate temp' – not accepted.

9. (c) One of the products of the fermentation process is frequently used as a solvent for both polar and non-polar solutes. Account for ethanol's ability to do this. 3

(c) Ethanol



small non-polar gp. / enables ethanol to form dispersion forces with non-polar substances eg I2, hydrocarbons.

polar end. enables ethanol to form H-bond bonds and dipole-dipole forces with polar molecules. eg H_2O, glucose,

Good account - including polar + non-polar sections of ethanol molecule
- types of i/m forces possible with polar + non-polar ends of molecule.
- egs of polar + non-polar solutes

Marks
(3)

Reasonable account (2)

Some description of ethanol as a solvent - eg like dissolves like

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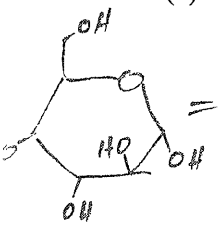
Section I – Part B (continued)

Marks

Question 20 (5 marks)

Fossil fuels, which at present make up the bulk of the raw material used in the plastics industry, are a finite resource and likely to become severely depleted in the near future. Biopolymers have been suggested as a possible replacement for the petrochemicals produced from fossil fuels.

(a) Cellulose is often considered the most useful compound from which to produce biopolymers. Describe the structure of cellulose. **2**



= A

Cellulose is a polymer chain made from repeating glucose monomers, where every second monomer is inverted. ...A-V-A-V-A...

(b) (i) Identify a biopolymer which has recently been developed or is in the process of being developed, for commercial use. **1**

(eg) PHA (or another biopolymer)
(NB: ethanol is not a polymer!)

(ii) Name the specific enzyme or organism used to synthesise this biopolymer. **1**

(eg) Alcaligenes eutrophes

(c) Suggest one benefit (apart from their renewability), of using biomass to produce polymers. **1**

• Biopolymers generally are biodegradable
OR • Conservation of crude oil for use as fuel
OR • (+ others)

Marks

Question 21 (3 marks)

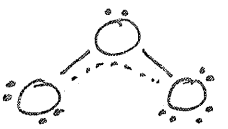
(a) Draw electron dot diagrams to show:

(i) an oxygen molecule. 1

Generally well done

(ii) an ozone molecule. (– Must be bent!) 1

Is really a resonance structure – not in syllabus
∴ had to accept "incorrect" octet version.



(* Do NOT use O_3 as an example of a co-ordinate covalent bond – use NH_4^+ or H_3O^+)

(b) State the difference in stability of ozone gas and oxygen gas.

O_3 O_2

• unstable stable

OR (+ others)

Marks

Question 22 (3 marks)

Esters are produced by reaction of an alkanoic acid and an alcohol.

(a) Name a straight-chained alkanoic acid. **1**

Propanoic acid (or other)

(b) Name a primary alcohol. **1**

Ethanol (had to say 1-propanol etc if used C_3 or higher)

(c) Name the ester that would be produced by refluxing this acid with this alcohol. **1**

Ethyl propanoate (must be correct using (a) + (b))

Marks

Question 23 (7 marks)

Over time, the definitions of acids and bases have been refined. Using the historical development of ideas about acids, evaluate how advances in scientific understanding changed the direction of scientific thinking. 7

- ~1776 Lavoisier
- ~1810 Davy
- ~1884 Arrhenius
- ~1923 Bronsted/Lowry

} NB contains oxygen ≠ contains O_2 !!!
all in syllabus (p55)

"Over time" + "historical development" mean that the order was important!

MARKING GUIDLINES (See syllabus p 55)

Part A

• All 4 people (above) named – including their ideas – must be accurate & "in time"	(5)
• Omitted one person or error of idea	(4)
• Omitted two people or several errors	(3)
or omitted one person AND an error	
• Omitted two people AND several errors	(2)
• One person & idea correct	(1)

Part B EVALUATE – make a judgement based on .....
– determine the value of....

Excellent evaluation	(2)
Good evaluation	(1)

NB Did not accept a 'restatement of the question' as an evaluation.

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Section I – Part B (continued) CRIB

Marks

Question 24 (5 marks)

A student was investigating the acid/base nature of salts, by adding the dry solid salts one at a time to water and then testing their pH.

When he did this with ammonium chloride, he noted that the pH < 7, and assumed that the following action had occurred.

$$NH_4^+(aq) + H_2O(l) \rightleftharpoons NH_3(aq) + H_3O^+$$

(a) Why does the above equation illustrate a Brönsted-Lowry acid, rather than an Arrhenius acid? 2

No. Arrhenius acid - ionises in water to produce H^+ ions. The above system does not. (1)

Brönsted-Lowry acid - is defined as a proton donor. Both NH_4^+ & H_3O^+ donate a proton. (1)

(b) From the above equation, give one example of an acid and its conjugate base, respectively. 1

NH_4^+ & NH_3 OR $H_3O^+ + H_2O$

(c) Briefly outline how you would perform a first-hand investigation to determine the concentration of an acidic substance using a computer-based technology. 2

Accurate description of hardware (ie pH meter) – (1)

Conversion of raw data in to $[H^+]$ & then acid conc – (1)

Marks

Question 25 (3 marks)

(a) Identify two metallic ions which are found in hard water. 1

Mg^{2+} + Ca^{2+}

(b) Describe a simple method of determining the hardness of water in a school laboratory. 2

* Titrating (brief description) – 1 MARK
with EDTA – 1 MARK

OR

* Add soap & shake – 1 MARK
Description of method including comparison
to other / Standard – 1 MARK.

OR

* Any alternative that would work
+ description

Marks

Question 26 (6 marks)

$2ZnS_{(s)} + 3O_{2(g)} \rightarrow 2ZnO_{(s)} + 2SO_{2(g)}$

While we usually think of the air around us as neutral, the atmosphere naturally contains acidic oxides of carbon, nitrogen and sulfur.

(a) (i) Describe, using an equation, an example of a chemical reaction which releases sulfur dioxide. 2

OR $4FeS_{2(s)} + 11O_{2(g)} \rightarrow 2Fe_2O_{3(s)} + 8SO_{2(g)}$

OR $S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$ Perfect - 2 MARKS

OR $2H_2S_{(g)} + 3O_{2(g)} \rightarrow 2SO_{2(g)} + 2H_2O_{(g)}$ Any mistake (-1)

(ii) Identify a natural source of sulfur dioxide. 1

Volcanic eruptions OR Bush fires OR Decaying organic matter

(b) (i) Describe, using an equation, an example of a chemical reaction which releases an oxide of nitrogen. 2

$NH_4NO_{3(s)} \rightarrow N_2O_{(g)} + 2H_2O_{(g)}$

$O_{2(g)} + N_{2(g)} \rightarrow 2NO_{(g)}$ Perfect - 2 MARKS

$2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$ Any mistake (-1)

(ii) Identify a natural source of nitric oxide (NO), a gas that is capable of destroying ozone, and is involved in the production of photochemical smog. 1

Lightning

Marks

Question 27 (4 marks) ✱ many confused n/p with p/n

(a) Discuss the conditions under which nuclei are stable. (SEE p102) 2

neutron-to-proton ratio lies within narrow limits (1)

too massive (Z > 82)

OR n/p too low for first 20 then increases to ~ 1.3 } (1)

OR n/p too low K-capt / β^+ emits n/p too high β-decay

(b) The two equations below represent the formation of significant artificial isotopes: 2

$^{98}_{42}Mo + ^{1}_{0}n \rightarrow ^{99}_{42}Mo \rightarrow ^{99}_{43}Tc + ^{0}_{-1}\beta$

$^{14}_{7}N + ^{1}_{1}H \rightarrow ^{11}_{6}C + ^{4}_{2}He$

Tc-99 is the most widely used radioactive isotope for diagnostic studies in nuclear medicine. C-11 is incorporated into organic compounds and used as a tracer in positron emission tomography (PET).

NB not "use"

Discuss the production of commercial isotopes using these and / or other relevant examples.

neutron-rich isotopes like Tc-99 made in a nuclear reactor (1)

neutron-poor isotopes like C-11 made in a cyclotron (1)

(it is possible to make Tc-99 in a cyclotron but NOT by the process shown above)

* SEE pp 108/9

Marks

Question 28 (6 marks)

Galvanic cells were constructed using the metals A – E and the voltages measured under standard conditions. The results are shown in the table below.

Cell reaction	**$E°_{cell}$ / V**
$A + B^{2+} \rightarrow A^{2+} + B$	0.98
$B + D^{2+} \rightarrow B^{2+} + D$	1.05
$2C + B^{2+} \rightarrow 2C^{+} + B$	1.68
$B + B^{2+} \rightarrow B^{2+} + B$	0.00
$B + E^{2+} \rightarrow B^{2+} + E$	0.66

(a) Draw a labelled diagram of one of the cells used and identify clearly the reference cell. **3**

ALMOST NOBODY DID THIS !!

DIAG : 2× ½ cell
1 × salt bridge (1)
NEARLY DRAWN & CORRECTLY DRAWN (SCI CONV)

LABEL : M / M^{2+} ×2
Salt bridge (1)
e^- flow (OR) cathode // anode

ID the REF CELL B/B^{2+} ½ cell (1)

(b) Explain what is meant by standard conditions. **1**

1 atm (or 1 bar) ; 25°C (or 298K) ; all concs 1 M
(all 3 required) (1)

Question 28 continued on page 21

Marks

Question 28 (continued)

(c) Construct a table of standard (half-cell) potentials from the data collected. 1

	E°_{red} / V
$C^{+} + e^{-} \rightleftharpoons C$	−1.68
$A^{2+} + 2e^{-} \rightleftharpoons A$	−0.98
$B^{2+} + 2e^{-} \rightleftharpoons B$	0.00
$E^{2+} + 2e^{-} \rightleftharpoons E$	+0.66
$D^{2+} + 2e^{-} \rightleftharpoons D$	+1.05

ALL (1)

(d) (i) Identify the best reducing agent. 1

C (the most active metal)

(ii) Identify the best oxidising agent.

D^{2+} (ion of the least active metal)

BOTH (1)

⊛ METALS cannot be oxidising agents

Marks

Question 29 (8 marks)

Polyethylene is a chemical which has been of significant commercial importance in the past fifty years.

(a) Outline the major steps in the industrial production of polyethylene, from the raw material used, to the finished product. 3

FRACTIONAL DISTILLATION OF PETROLEUM / CRUDE OIL (1)

(CATALYTIC) CRACKING OF HIGHER FRACTIONS → ETHENE (1)

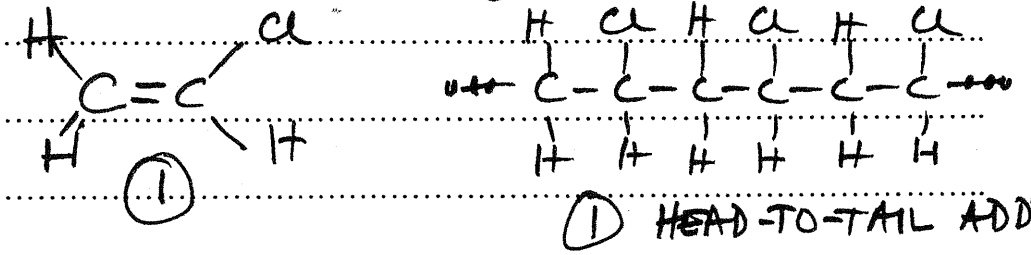
OR (ADDITION POLYMERISATION OF ETHENE (1)
POLN. in pres of catalyst &/or high T, P)

ANSWERS often contained much INCORRECT (or poorly expressed) detail.

(b) Many commercial polymers are produced by the modification of ethene molecules, such that a hydrogen is replaced by a side group, followed by a polymerisation reaction.

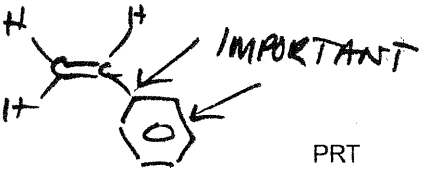
(i) Identify one such "modified ethene" monomer, either by its common or systematic name, and using complete structural formula, write an equation to represent the polymerisation reaction, using ~~three~~ monomer units. 3

Chloroethene or vinyl chloride (1) NOT POLYMER NAME



(1) HEAD-TO-TAIL ADDN.

MANY who chose styrene / phenylethene couldn't draw a benzene ring (phenyl group) or represent its connection to the vinyl group



Question 29 continued on page 23

Marks

Question 29 (continued) N.B.

(ii) Describe a use for the polymer you have identified, in part (i), in terms of its physical or chemical properties. **2**

(1) PROPERTY

(1) USE CONNECTED TO PROPERTY

(✱) REF/SOURCE pp 25/6

N.B. IF the property is the result of modification of the polymer by additives, formation of a foam etc, this had to be described explicitly in the answer. Thus, for example "PVC is flexible" is incorrect (sup 25)

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The Chemistry of Art.

a(i) arsenic(III) sulfide (1)

(ii) Pigments can be inhaled as dust
ingested (from hands)
absorbed through cuts
} (1) any two

OR

Pb/Hg compounds are toxic } affect CNS
As/Sb compounds are toxic } body treats them like P } (1)
(1)

www.conmeg.com/sub/artpage/ART/ARTHmedieval.html

(b) (i) A paint consists of a pigment (1)
and a medium (binder)

(ii) The support is prepared by a layer of gesso
The paint is applied as egg tempera (1) pigment
mixed with egg yolk

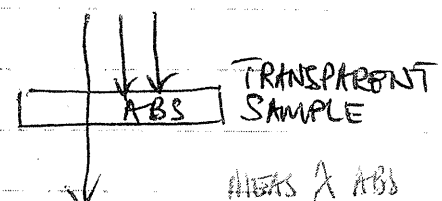
NB NOT TEMPURA

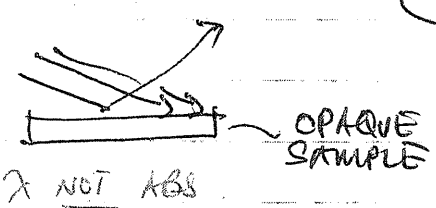
"St John the Baptist with St John the Evangelist & St James" (1)

SIMPLE AND ENHANCED

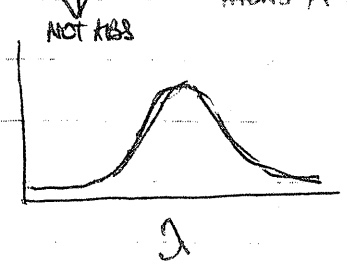
SPECTRUM (S)
SPECTRA (PL)
(c)

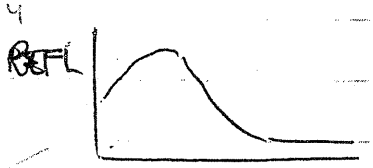
NOT: ATOMIC spectra





(1) "Complementarity"





(1)

(1) A plot of absorption intensity (amt of light abs) against wavelength

A plot of intensity of refl. light against wavelength

OR

(1) Absorption associated with changes in $\bar{e}$ energy levels.

CHEM OF ART

(2)

(d) (1) STATE FEATURES

- Sharp, discrete lines
- ABS black lines on coloured background
- EMI coloured lines on black background.
- Freq / λ of abs & em lines are the same.

(1) E emitted when $\bar{e}$ move from higher E-level to a lower
E abs when $\bar{e}$ move from lower E-level to a higher

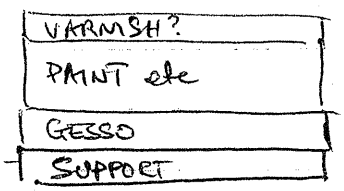
(1) EXPLAIN FEATURES

Atoms with many electrons have more E-levels and more complex spectra than H.

Must refer to ~~spectra~~ diagrams given (say which is which ...)

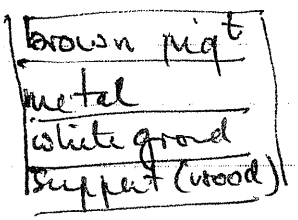
Q "EXPLAIN"

(e)



Pulses dig down (1)

ATOMS ID BY ATOMIC emission spectra



5th pulse brown pigment Fe present Fe_2O_3 (1)
(Ca & Na don't form coloured compounds) $FeO(OH)$

10th pulse metallic layer Ag present Ag (1)
(Ca is a very reactive metal)

14th pulse white ground Ca present $CaSO_4 \cdot xH_2O$ (1)
($CaCO_3$ (?) less likely)

30

CR1B-AKBB

ai eg Rubber – 1 MARK.

ii eg Styrene butadiene or neoprene – 1 MARK.

iii eg historical context WW II Japan/America.
or cost/efficiency
or no need for land clearance etc 1 MARK.
NB. Simply stating demand was not sufficient.

bi Any specific example of H_2SO_4 as a dehydrating agent. (ie Sucrose or – 1 MARK.

Accepted this time (H_2SO_4 acting as a catalyst in dehyd. reaction
but NOT GOOD examples OR dehydrating system in Eqn.

ii Conc H_2SO_4 plus example of oxidation – 1 MARK

Equation to represent this oxidation process – 1 MARK.
OR Simple redox oxidation < equation – 1 MARK
identification of oxidised species 1 MARK

c. $K = \dfrac{[CO][Cl_2]}{[COCl_2]}$ – 1 MARK.

$[Cl_2] = 0.08m, [CO] = 0.08m, [COCl_2] = 0.02M$ 1-MARK

$K = \dfrac{0.08^2}{0.02} = \underline{\underline{0.32}}$ 1 MARK

d.

$H_2SO_{4(l)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + HSO_4^-{}_{(aq)} + Heat$

* extremely exothermic therefore may spit

Essential to add acid to water slowly (stirring) rather than vice versa so at worst only dilute acid will spit. 1-MARK

* $C_1V_1 = C_2V_2$ or actual calculation 1-MARK
  or H_2SO_4 1 : 8 H_2O

* Must wear safety specs, gloves and protective clothing. 1-MARK.

OR If reasonable attempt at 2 or more of above points – 1 MARK

e. One tick does NOT equal one mark.!!

1 use mentioned – 0 MARKS
2 uses mentioned – 1 MARK
3 uses mentioned – 2 MARKS

PLUS

Details or equation of 1 use – 1 MARK
Details or equations of 2 uses – 2 MARKS.

NB- The production of ethene from ethanol is not currently a significant industrial process