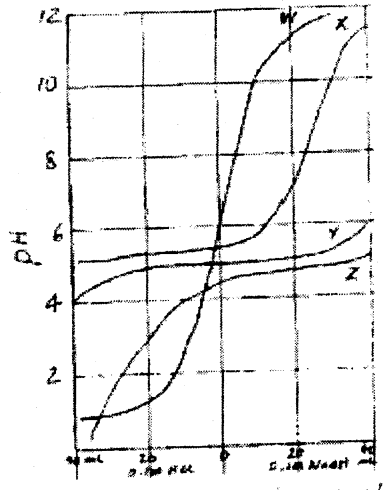
Revision questions (JR 01, Syd Girls 01, Prior 01, Newington 01)

8 Which of the following species is the strongest base?

(A) CH_3CH_2OH
(B) NO_3^-
(C) CH_3COO^-
(D) HSO_4^-

10. The graph below shows buffer solutions W, X, Y, and Z reacting with varying amounts of 0.1 mol L^{-1} HCl and 0.1 mol L^{-1} NaOH.



volume of 2 solutions

MAKING

100ml 0·1M CH_3COOH.
add 100ml 0·1M CH_3COO^-
with sodium acetate.
$NaCH_3COO$

Which solution is the most effective buffer in this situation?

(A) W
(B) X
(C) Y
(D) Z

(b) The composition of the atmosphere is given in the table below.

Gas	Concentration (%v/v)
X	78.09
Y	20.94

(i) Identify the gases X and Y

X nitrogen Y oxygen 2

(ii) Calculate the concentration of Y in ppm. Show your working 2

20·94 % v/v

0·2094 × 10^6 20·94ml / 100ml

= 209400 ppm ml / 1000ml ppm → 10

ml / L mg/kg

2

otherwise

Question 22 (6 marks)

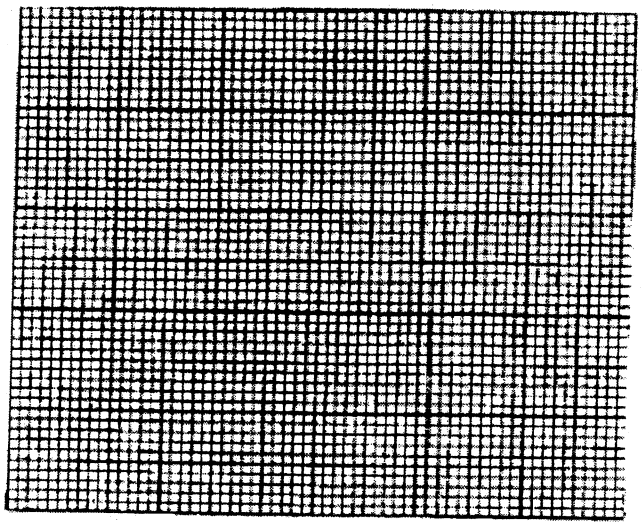
Marks

A sample of river water was analysed for copper by atomic absorption spectrophotometry (AAS). A 25.00 mL water sample was diluted to 250.0 mL with demineralised water and directly measured with the AAS instrument. An average absorbance reading of 0.400 was obtained. The standard solutions were prepared by dissolving copper metal in nitric acid and diluting with demineralised water. A series of standards were prepared. The final concentrations of the standards were: 3.48×10^{-6}, 5.24×10^{-6} and 6.97×10^{-6} g mL^{-1} copper. The average absorbance readings for the standards were 0.313, 0.460 and 0.600 respectively.

(a) Construct a table of results giving details of the concentrations of the standards and their corresponding readings. Include in your table the unknown and its average reading. **2**

Concentration (g/mL)	Absorbance
3.48×10^{-6}	
?	0.400 g

(b) Construct a labelled graph of readings against concentration of the standards. **2**



(c) Using the graph, determine the concentration of copper in the original sample of river water in g mL^{-1} and in p.p.m. **2**

.....

.....

.....

.....

g. 4.5×10^{-6} g/mL.

$\times 10$ (dilution)

4.5×10^{-5} g/mL. $\times 10^{6}$

mg/kg

~~ml / 1000 L~~

make an assumption

$d = 1.0$ g/mL.

Question 30 (4 marks) **Marks**

Phosphorus –32 is a radioisotope with a half life of 14 days.

(a) Write a nuclear equation for the beta decay of phosphorus-32. 1

$^{32}_{15}P \rightarrow {}^{0}_{-1}e + {}^{32}_{16}S$

(b) Explain the term "half-life". 1

The time taken for ½ the origin mass to decay.

(c) Nuclear reactors use high speed neutrons and are used to produce neutron-rich isotopes. A neutron –rich isotope contains more neutrons in its nucleus than most other atoms of the element, such as cobalt-60 or strontium-90. To make neutron deficient radioisotopes, a cyclotron is used. Use the periodic table to complete the table below: Explain your answer. 2

Isotope	Method of production
oxygen-18	nuclear reactor

Because normally oxygen has a mass of 16, thus 2 neutrons have been bombarded into the oxygen nucleus

Question 32 (2 marks) **Marks**

A solution of ethanoic acid has the same pH (3.0) as a solution of HCl.
Equal aliquots of each acid solution are titrated with 0.10 mol L^{-1} NaOH.

(a) Which acid will require a greater titre (volume) of base for neutralisation? Explain your answer. 1

Since they are at the same pH, but ethanoic acid is a weak acid, ethanoic acid must be more concentrated thus more NaOH is needed to neutralise ethanoic acid.

(b) Choose a suitable indicator from the table in *Question 31* for the CH_3COOH –NaOH titration and give a reason. 1

phenolypthalein, this titration has equivalence point above 7.

Question 33 (2 marks)

$NaHCO_3$

Sodium hydrogen carbonate is a common salt which forms an alkaline aqueous solution.

(a) Write an equation showing sodium hydrogen carbonate dissolving in water. 1

$NaHCO_{3(s)} \longrightarrow Na^+_{(aq)} + HCO_3^-{}_{(aq)}$

(b) Write another equation which explains why hydrogen carbonate ions cause the solution to be basic. 1

$HCO_3^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons OH^-_{(aq)} + H_2CO_{3(aq)}$

Question 34 (2 marks) **Marks**

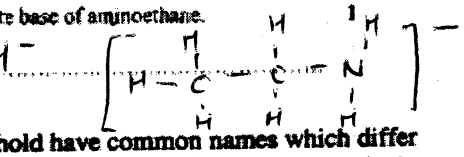
Aminoethane is an amphiprotic liquid which is soluble in water.
The equation below shows aminoethane acting as an acid in water solution.

$$CH_3CH_2NH_2(l) + H_2O(l) \rightleftharpoons CH_3CH_2NH^-(aq) + H_3O^+(aq)$$

(a) Write a balanced equation showing aminoethane acting as a base in water solution

$CH_3CH_2NH_2(l) + H_2O(l) \rightleftharpoons OH^-(aq) + CH_3CH_2NH_3^+(aq)$ 1

(b) Write the structural formula of the conjugate base of aminoethane.

$CH_3CH_2NH^-$  1

2 Many substances found in the household have common names which differ from those used in the laboratory. Three examples of household chemicals are:

baking soda, vitamin C, vinegar.

The correct chemical name for each (in order) is:

(A) sodium bicarbonate, acetylsalicylic acid, hydrochloric acid.
(B) sodium hydroxide, citric acid, acetic acid(aq).
(C) sodium hydrogencarbonate, ascorbic acid, ethanoic acid(aq).
(D) carbonic acid, 2-hydroxypropane-1,2,3-tricarboxylic acid, ethanedioic acid.

5 Scientific instrumentation used in chemical analysis is made to exploit one or more chemical principles. Which of the following lists an instrument with a correct principle upon which it relies?

(A) AAS: electrons in anions emit characteristic wavelengths when allowed to relax after being excited by a flame.
(B) UV-visible spectrometer: chemical species in solution absorb characteristic wavelengths but the intensity of absorption is unrelated to concentration.
(C) AAS: atoms emit photons of light when nuclear transitions are allowed.
(D) UV-visible spectrometer: chemical species absorb UV-visible light if the energy of photons corresponds to that required for electronic transitions.

10 When a strip of cleaned magnesium is added to a solution of copper sulfate a metal displacement reaction occurs. The magnesium seems to disappear and solid copper deposits at the bottom of the beaker. This occurs because:

(A) the magnesium is more electronegative than the copper.
(B) the copper displaces the magnesium from solution.
(C) magnesium is more soluble than copper.
(D) the pull of the copper ions on electrons is greater than that of magnesium ions.

13 Which of the following best describes the positive result of a standard qualitative determination of Cu^{2+} ions?

(A) Addition of OH^- precipitates a blue solid which redissolves in $NH_3(aq)$ to give a deep blue solution.
(B) Addition of OH^- gives a green precipitate which quickly turns brown in air.
(C) Addition of SCN^- gives a deep red solution.
(D) Addition of SO_4^{2-} gives a white precipitate, but addition of F^- or OH^- does not.

15 Data obtained from various combustion experiments is given in the table below.

Fuel	CH_3OH	C_2H_5OH	C_3H_7OH	C_4H_9OH
MW(g/mol)	32	46	60	74
Mass used (g)	1.74	1.83	1.39	1.47
Moles used	0.0544	0.0398	0.0232	0.0199
Mass H_2O (g)	300	300	300	300
$\Delta T_{(water)}$ (°C)	+17.4	+18.9	+17.7	+21
$Q_{(water)}$ (kJ)	+21.4	+23.7	+22.2	+26.3

According to this set of experimental data the heat of combustion of ethanol is:

(A) 394 kJ/mol.
(B) 595 kJ/mol.
(C) 2487 kJ/mol.
(D) 515 kJ/mol.

$-23.7 / 0.0548$

Question 25 (6 marks) **Marks**

At the turn of the century (19th / 20th) Arrhenius established the existence of ions in solution, and this advance in scientific understanding was used by him to change the way chemists thought about acids and bases. Later Bronsted and Lowry independently suggested a new definition of acids and bases.

(a) What was the Lowry-Bronsted definition? **2**

Acids are substance which ... in different solvent — role of the solvent — chemicals can sometimes be acting an an acid, ... why things

(b) What was one advantage of the new definition for scientific chemical thinking? **1**

Previous definitions described acids/bases based only on their composition

Bronsted & Lowry described acids & base based on their interaction with other species / other solvent. This allowed amphiprotic substances to be accounted for which can act as both acid and base depending on the solvent they are in.

(c) Name an example of an amphiprotic ion and explain using chemical equations what is meant by "amphiprotic". **3**

HCO_3^-

$HCO_3^- + OH^- \rightleftharpoons CO_3^{2-}(aq) + H_2O(l)$

$HCO_3^- + H_3O^+ \rightleftharpoons H_2CO_3(aq) + H_2O(l)$

Question 29 (7 marks) **Marks**

2.0 L of concentrated (10M) hydrochloric acid was spilled in a laboratory accident.

Three substances were considered for use to minimise the damage, solid sodium hydrogencarbonate, powdered limestone (calcium carbonate) and 2M sodium hydroxide solution.

(a) **Calculate the minimum mass of calcium carbonate needed to neutralise the acid. Show numerical working.** **3**

$CaCO_3 + 2HCl \rightarrow H_2O_{(l)} + CaCl_2 + CO_{2(g)}$

$n(HCl) = C \cdot V$

$= 10 \times 2$

$= 20$ moles

$n(CaCO_3) = 10$ moles.

mass $= n \cdot M$

$= 10 \times 100.08$

$= 1000.8$ g.

(b) **Assess each of the three for use in the neutralisation of the spilt acid.** **4**

produce less gas?

① Solid sodium hydrogencarbonate → solid easy to handle.

→ weak base : safe, produces less heat while exothermic reaction.

→ can put excess and not dangerous because weak again.

② Powdered limestone → solid / powdered → easy to handle

→ weak base : safe

→ can put use in excess.

$NaOH$ ⇒ solution, difficult to handle.

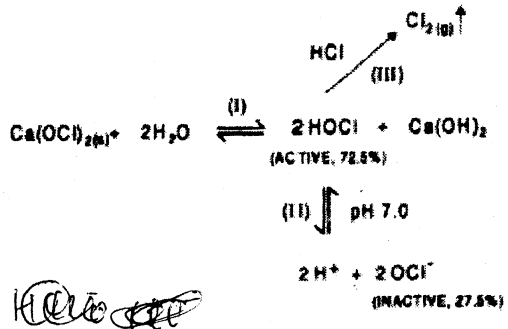
⇒ V · ~~Na~~ concentration

⇒ too ~~corrassive~~ corrosive

⇒ fast reaction → exothermic too much heat

Question 30 (6 marks) **Marks**

The use of chlorine as an algaecide in the sanitisation of swimming pools can be explained by the following chemical reactions.



Solid calcium hypochlorite reacts with water to produce hypochlorous acid which is the active constituent.

At a pH of 7.0, 27.5% of the acid ionises to give inactive hypochlorite ion. The remaining hypochlorous acid results in chlorine available for sanitisation.

(a) **What is meant by "pH of 7.0"?** **1**

pH ~~refers~~ is a measure of the hydronium concentration in a ~~the~~ solution $pH = -\log[H^+]$

$[H^+] = 10^{-7}$.

(b) **Comment on the strength of hypochlorous acid.** **2**

Hypochlorous is a weak acid, only 27.5% ionises.

(c) **Explain in terms of Le Chatelier's principle the effect of adding HCl on the solubility of calcium hypochlorite.** **3**

By adding HCl, equation 3 occurs, which reduces the concentration of HOCl, the equilibrium (1) shifts to the right → more dissolving

3 Which of the following nuclear equations relates to the production of a transuranic element in a nuclear reactor?

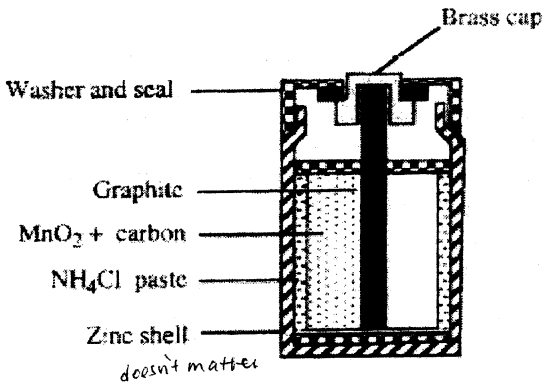
(A) $^{226}_{88}Ra \rightarrow {}^{226}_{82}Rn + {}^{4}_{2}He$

(B) $^{229}_{89}Ac \rightarrow {}^{229}_{90}Th + {}^{0}_{-1}e$

(C) $^{234}_{92}U + {}^{4}_{2}He \rightarrow {}^{230}_{90}Th$

(D) $^{238}_{92}U + {}^{1}_{0}n \rightarrow {}^{239}_{93}Np + {}^{0}_{-1}e$

5 There are a number of galvanic cells which are commonly used. A diagram of a dry or Le Clanche cell is illustrated below.



The overall reaction in this cell can be represented as

$$Zn_{(s)} + 2NH_4^+ + 2MnO_{2(aq)} \rightarrow Zn^{2+} + Mn_2O_{3(s)} + 2NH_{3(aq)} + H_2O_{(l)}$$

In this cell,

(A) Zn is acting as the cathode and is being reduced to Zn^{2+}.

(B) The manganese in MnO_2 is being reduced as its oxidation number changes from +4 to +3.

(C) The ammonium ion is acting as the oxidant.

(D) The graphite rod is negative.

14 A student analyses a sample of water from a local river for a number of ions. His results are summarised in the table below.

Test	Result
addition of barium nitrate solution	white precipitate forms
addition of silver nitrate solution	white precipitate forms

The identity of the two precipitates is likely to be

(A) barium sulphate and silver chloride.

(B) sodium nitrate for both.

(C) barium oxide and silver bromide.

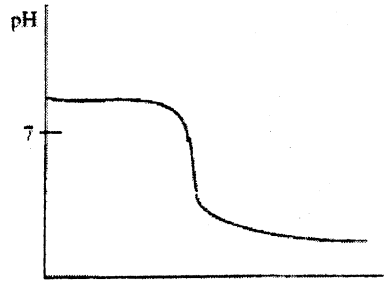
(D) magnesium nitrate and lead nitrate.

7 A 1.0 M solution of hydrochloric acid is titrated against solution of ammonia

$$NH_{3(aq)} + HCl_{(aq)} \rightarrow NH_4Cl_{(aq)}$$

NH_4^+ is an acidic salt.

The pH curve for the titration is shown below.



The equivalence point is at a pH

(A) less than 7 as the principal species at the equivalence point include the ammonium ion which is a Bronsted-Lowry acid.

(B) is 7 as the ammonia has neutralised the hydrochloric acid.

(C) is greater than 7 as hydrochloric acid is a strong acid and ammonia is a relatively weak base.

(D) is less than 7 as hydrochloric acid is in excess at the equivalence point.

Question 25 (continued) **Marks**

(c) Define the term biological oxygen demand (BOD). How is BOD measured? **3**

BOD → is the oxygen required by aerobic bacteria to decompose organic matter in a sample of water.

Question 19 (5 marks) **Marks**

The table below shows the atmospheric levels of different gases in two different urban areas.

Component of air	Clean air	Urban Area P	Urban Area Q
Ozone (ppm)	0.02	0.22	0.05

(a) Calculate the concentration of ozone gas in urban area P in $mol\,L^{-1}$. Assume the atmospheric pressure was 101.3 kPa and the temperature 298 K when the measurements were taken. **2**

$0.22\,L \rightarrow 10^6\,L$ ~~0.02 mg/L~~

$\frac{0.22}{10^6}\,L \times 1\,L \quad 2\times10^{-5}\,g\,L$ mass → n

$= 2\times10^{-5}$

$n = \frac{\text{Volume}}{24.79}$ $8.87\times10^{-9}\,mol\,L^{-1}$

$V = n \times 24.79$

0.22 ppm

$0.22\ mol/L$

$V = 0.22\times10^{-6}\,L/L$

$n = \frac{V}{24.79}$

$n = \frac{m}{M}$ $n = \frac{\text{Volume}}{24.79}$

(b) Urban area P has elevated ozone levels.

(i) Suggest a possible source for the ozone gas. Write a balanced chemical equation or equations for the formation of ozone gas. **2**

$NO_2 \xrightarrow{U.V} NO + O$

$O + O_2 \rightarrow O_{3(g)}$

(ii) What environmental / health impact may this have? **1**

oxidises molecules in your body -

respiratory problems -

(b) Describe the trend in the acidic/basic nature of the third period oxides. Your answer should include chemical equations to show the acidic/basic nature of at least one basic oxide and one acidic oxide. **3**

$Na_2O + H_2O \xrightarrow{Na} NaOH$ SO_3

$CO_2 + H_2O \rightarrow H_2CO_3$

~~As you move across the period to the right, elements become~~

The metallic oxides on the left of the table ~~are~~ become metallic when in the presence of water,

eg $2Na_{(s)} + H_2O_{(l)} \rightarrow H_{2(g)} + NaO_2$

As you move across the period the semimetals tend to be amphiprotic

On the right hand side are non-metals which are always acidic in water

eg. $SO_3 + H_2O \rightarrow H_2SO_4$.

Question 21 (4 marks) **Marks**

Consider the following species.

CO_3^{2-} H_2SO_4 NH_3 OH^- NH_4^+

(a) Which species will act as Lowry-Bronsted bases? Why? **2**

CO_3^{2-} NH_3 CO_3^{2-}, NH_3, OH^- are able act as Lowry-Bronsted bases, this is because they are all capable of accepting a proton.

CO_3^{2-} / HCO_3^- NH_3 / NH_4^+ OH^- / H_2O

(b) Write a equation to show the species you selected in part (a) acting as a base with one of the other species listed. **1**

$CO_3^{2-} + NH_4^+ \rightarrow HCO_3^- + NH_3$

$CO_{3(aq)}^{2-} + H_2SO_{4(aq)} \longrightarrow HCO_{3(aq)}^- + HSO_{4(aq)}^-$

(c) Which species is amphiprotic? **1**

NH_3 NH_3

Question 27 (3 marks) **Marks**

In your studies you have come across a number of catalysts. **3**

Name one such catalyst and the reaction it which it is employed. **Describe** the role of the catalyst in this reaction and **propose** a model to account for its effect.

9 When a piece of copper wire is placed in silver nitrate solution the wire becomes coated with crystals of silver metal. What is the oxidant in this reaction?

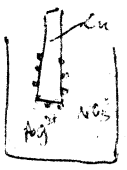
(A) Cu

(B) Ag^+

(C) NO_3^-

(D) H_2O

$Cu_{(s)} + Ag(NO_3)_2$



12 A sample of powder is known to be either sodium carbonate or sodium phosphate. The most appropriate test to identify the substance is

(A) add water

(B) add hydrochloric acid

(C) add sodium hydroxide solution

(D) heat the sample over a Bunsen burner

Na_2CO_3 Na_3PO_4

Question 21 (2 marks)

When pellets containing molybdenum-98 are placed (in steel rods) in the nuclear reactor, neutrons are absorbed and molybdenum-99 is formed as shown in the nuclear equation below.

$$^{98}Mo \quad {}^{1}n \longrightarrow {}^{99}Mo$$

(a) Molybdenum-99 is an unstable isotope and undergoes beta decay to form technetium-99. Write a nuclear equation for the beta decay of molybdenum-99. 1

$^{99}Mo \longrightarrow {}^{0}_{-1}e + {}^{99}Tch$

(b) Technetium-99 can be used to detect bone cancer. Once it is injected, the technetium-99 attaches itself to the parts of the bone that have cancer and emit radiation which can be detected by a "camera" outside the body.

Name a device which could be used as the camera. 1

radiation detector containing photographic paper.

Question 22 (3 marks)

Carbon dioxide is poorly soluble. Small amounts of carbon dioxide can be dissolved in water and like nearly all gases it is more soluble in cold water.

(a) Write an equation showing carbon dioxide in water. Explain in terms of Le Chatelier's Principle why high pressure carbon dioxide is used to increase the amount which dissolves. 2

$CO_2(g) \xrightleftharpoons{H_2O} CO_2(aq)$

$CO_2(g) + H_2O(l) \rightleftharpoons H_2CO_3(aq) + H_2O \rightleftharpoons HCO_3^- + H_3O^+$

In the equation, it shows 2 moles of reactants ⇌ forming 1 mole of product. Thus by increasing pressure, the system will shift to counteract the change, shifting in the direction to reduce pressure. making a smaller → 1 mole ∴ more is dissolves for more formed. according to Le Chat.

(b) Suggest a reason why more gas dissolves at lower temperature.

$CO_2(g) \rightleftharpoons CO_2(aq) + Heat$, exothermic reaction will cause favour the forward reaction

(c) The purification and treatment of Sydney tap water can be considered as five steps.

aeration , chlorination , filtration , fluoridation , sedimentation

List these steps in the correct order. 2

aeration

sedimentation

filtration

chlorination

fluoridation