ATAR course examination, Semester 1, 2021

Answer Key

Section One: Multiple–choice **(25 Marks)**

1	A
2	C
3	B
4	D
5	D
6	B
7	B
8	B
9	C
10	A
11	B
12	A
13	C

14	B
15	D
16	C
17	A
18	B
19	D
20	D
21	D
22	B
23	C
24	D
25	A

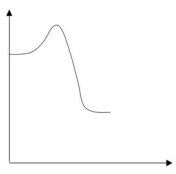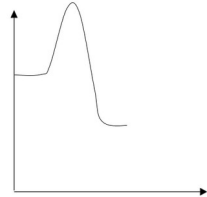| A = 5 |
|---|
| B = 8 |
| C = 5 |
| D = 7 |

Section Two: Short answer **(80 Marks)**

Question 26 **(7 marks)**

(a)   Sketch energy profile diagrams for each of these reactions.   (3 marks)

Description	Marks
Phosphorus reaction correct exothermic shape 	1
Potassium chlorate reaction correct exothermic shape 	1
Phosphorus reaction has much lower activation energy that potassium chlorate reaction	1
Total	**3**

(b) Write a balanced equation for the decomposition of potassium chlorate including the heat of reaction and state symbols. $\Delta H = -98.56$ kJ (3 marks)

Description	Marks
Equation correctly balanced: $2\ KC\ell O_3(s)\ \rightarrow\ 2\ KC\ell(s)\ +\ 3\ O_2(g)\ +\ 98.56$ kJ	1
State symbols correct	1
Heat on rhs	1
Total	**3**

(c) State one reason why the experimental value obtained is lower than the theoretical value. (1 mark)

Description	Marks
Loss of heat to the surroundings	1
Total	**1**

Question 27 (4 marks)

Using ethanoic acid as an example, distinguish between the definition of the term 'acid' in the Davy and the Brønsted–Lowry models. Include relevant equations in your answer.

Description	Marks
Davy	
An acid contains replaceable hydrogen	1
$2\ CH_3COOH(aq)\ +\ Mg(s)\ \rightarrow\ H_2(g)\ +\ Mg(CH_3COO)_2\ (aq)$	1
Brønsted-Lowry	
An acid donates hydrogen ions/protons	1
$CH_3COOH(aq)\ +\ H_2O(\ell)\ \rightarrow\ H_3O^+(aq)\ +\ CH_3COO^-(aq)$	1
Total	**4**

Question 28 (8 marks)

Write four (4) half-equations representing the steps in the sulfur cycle described above, assuming acidic conditions. Classify each step as a reduction (R) or oxidation (O) process.

Description	Marks
Step 1: $8\ H_2S\ \rightarrow\ S_8\ +\ 16\ H^+\ +\ 16\ e^-$	
Correct half-equation	1
Oxidation (O)	1
Step 2: $S_8\ +\ 32\ H_2O\ \rightarrow\ 8\ SO_4^{2-}\ +\ 64\ H^+\ +\ 48\ e^-$	
Correct half-equation	1
Oxidation (O)	1
Step 3: $SO_4^{2-}\ +\ 2\ H^+\ +\ 2\ e^-\ \rightarrow\ SO_3^{2-}\ +\ H_2O$	
Correct half-equation	1
Reduction (R)	1
Step 4: $SO_3^{2-}\ +\ 8\ H^+\ +\ 6\ e^-\ \rightarrow\ H_2S\ +\ 3\ H_2O$	
Correct half-equation	1
Reduction (R)	1
Total	8

Question 29 **(15 marks)**

An investigation into the oxidising strength of various metals was set up as shown below initially comparing copper and magnesium.

(a)   Label the anode and cathode.   (1 mark)

Description	Marks
Mg = anode and Cu = cathode	1
Total	1

(b)   Write the overall redox equation and calculate the cell voltage under standard conditions.
                                                                                                                              (2 marks)

Description	Marks
$Cu^{2+}(aq) + Mg(s) \rightarrow Cu(s) + Mg^{2+}(aq)$	1
Cell voltage = + 2.70 V	1
Total	2

(c)   Name suitable electrolyte solutions for each beaker.   (2 marks)

Description	Marks
Magnesium: magnesium nitrate/sulfate	1
Copper: copper nitrate/sulfate	1
Total	2

The voltage measured was initially higher than predicted then slowly decreased.

(d)   Explain this observation.   (2 marks)

Description	Marks
Higher: was greater than 1 mol L^{-1} Cu^{2+}	1
Decreased: concentration of Cu^{2+} decreased so voltage decreases	1
Total	2

(e)   State two observations for the copper half–cell as the reaction proceeds.   (2 marks)

Description	Marks
Solution: became less blue	1
Electrode: became larger	1
Total	2

As part of the experiment the student weighed both electrodes before and after the experiment and found one electrode increased by 0.253 g.

(f)   Calculate the mass change in the other electrode.   (3 marks)

Description	Marks
Identifies Cu electrode increases by 0.253 g	1
n(Cu) = 0.253 ÷ 63.55 = 0.00398 = n(Mg)	1
m(Mg) electrode change = 0.00398 × 24.31 = 0.096 g decrease (must state decrease)	1
Total	3

The equipment shown above compares the oxidising strength of copper and magnesium.

(g)   How could the oxidising strength of zinc be determined using this equipment?   (3 marks)

Description	Marks
Replace Mg with zinc and measure cell voltage	1
If voltage +ve then zinc is more readily oxidised than copper	1
Use size of voltage to compare oxidising strength to magnesium	1
Total	3

Question 30 **(6 marks)**

Write balanced equation for reactions occurring between the following substances and describe observations during the reaction and the contents of the flask at the end of the reaction.

(a) A small amount of aqueous chlorine is added to some potassium iodide solution.

(3 marks)

Description	Marks
Equation $Cl_2(aq) + 2\,I^-(aq) \rightarrow I_2(aq) + 2\,Cl^-(aq)$	1
Observation(s) during the reaction Pale yellow solution added to a colourless solution; solution becomes brown	1
Contents of flask when reaction has finished Light brown solution	1
Total	3

(b) A large volume of sodium hydroxide solution is added to a small volume of sulfuric acid containing a few drops of phenolphthalein. (3 marks)

Description	Marks
Equation $OH^-(aq) + H^+(aq) \rightarrow H_2O(\ell)$	1
Observation(s) during the reaction 2 colourless solutions mixed; solution turns pink	1
Contents of flask when reaction has finished Pink solution	1
Total	3

Question 31 **(15 marks)**

(a) Determine by calculation if this sample of rock should be considered limestone. (8 marks)

Description	Marks
$n(NaOH) = 2.004 \times 0.0300 = 0.06012$ mol	1
$n(HCl)$ excess $= n(NaOH) = 0.06012$	1
$n(HCl)$ added $= 0.5030 \times 0.2000 = 0.1006$	1
$n(HCl)$ reacting with $CaCO_3 = 0.1006 - 0.06012 = 0.04048$ mol	1
$n(CaCO_3) = \frac{1}{2} \times n(HCl) = 0.02024$ mol	1
$m(CaCO_3) = 0.02024 \times 100.09 = 2.02582$ g	1
$\%CaCO_3 = 2.0258/3.75 \times 100 = 54.02\ \%$	1
Yes limestone as sample is more than 50% $CaCO_3$	1
Total	8

(b) Explain how this reaction will behave differently if it is carried out in an open container compared with a closed container. (2 marks)

Description	Marks
In an open container bubbles of CO_2 gas will escape and all the solid $CaCO_3$ will convert to CaO.	1
In a closed container CO_2 gas can recombine with CaO and the reverse reaction can occur	1
Total	2

(c) Write the equilibrium expression for this reaction. (1 mark)

Description	Marks
$K = [CO_2]$	1
Total	1

(d)   Compare the relative amounts of products and reactants at equilibrium.   (1 mark)

Description	Marks
Reactants > products	1
Total	1

(e)   Predict the effect on K of reducing the temperature. Justify your answer.

(3 marks)

Description	Marks
K decreases	1
Temp decrease favours exothermic reverse reaction	1
Reducing $[CO_2]$ (and therefore reducing K)	1
Total	3

Question 32   (7 marks)

(a)   Write the equation for the reaction of the dihydrogen phosphate ion with water.   (2 marks)

Description	Marks
$H_2PO_4^-(aq) + H_2O(\ell) \rightleftharpoons HPO_4^{2-}(aq) + H_3O^+(aq)$	2
One minor error or no $\rightleftharpoons$	1
Total	2

(b)   Which one of the following reactions will be more likely to take place? Explain your
answer by referring to the relative strength of the conjugate acids and bases present.

(5 marks)

Description	Marks
Equation #1	1
Ka for 3rd ionisation (removal of 3rd H) = 4.8×10^{-13}	1
Kw for water is 1×10^{-14}	1
$HPO_4^{2-}(aq)$ is therefore a slightly stronger acid than $H_2O(\ell)$	1
So $HPO_4^{2-}(aq)$ will donate a proton to $H_2O(\ell)$ (as shown in equation 1)	1
Total	5

Question 33 **(10 marks)**

(a)   Describe the initial effect of lactic acid on the pH of blood.   (2 marks)

Description	Marks
Increases $[H^+]$	1
Decreases pH	1
Total	**2**

(b)   Explain, using collision theory, how the buffer acts to reduce the impact of lactic acid.

(4 marks)

Description	Marks
Increased $[H^+$/lactic acid] increases rate of collisions between reacting particles	1
This increases the rate of the forward reaction relative to the reverse rate	1
This reduces the $[H^+]$ as it is used up in the forward reaction	1
Returning the $[H^+]$ close to its original value so maintaining pH of the buffer	1
Total	**4**

(c)   Explain how both these processes can help maintain normal pH.   (4 marks)

Description	Marks
Lungs xs $[CO_2]$ causes reverse reaction to be favoured increasing $[H^+]$ and decreasing pH	1
Removing CO_2 reverses this - maintaining pH	1
Kidneys xs $[HCO_3^-]$ causes forward reaction to be decreasing $[H^+]$ and increasing pH	1
Removing HCO_3^- reverses this - maintaining pH	1
Total	**4**

Question 34 **(8 marks)**

(a)   Calculate the mass of barium hydroxide solid required to neutralise 45.0 mL of a
       hydrochloric acid solution at pH = 1.52.   (6 marks)

Description	Marks
H^+	
$[H^+] = -10^{-1.52} = 3.019951 \times 10^{-2}$	1
$n(H^+) = 0.0450 \times 3.019951 \times 10^{-2} = 1.358 \times 10^{-3}$ mol	1
OH^-	
$H^+ + OH^- \rightarrow H_2O$ or states stoichiometry $n(H^+) = n(OH^-) = 1.358 \times 10^{-3}$ mol	1
$\therefore n(Ba(OH)_2) = 1.358 \times 10^{-3} \div 2 = 6.79489 \times 10^{-4}$ mol	1
$M(Ba(OH)_2) = 171.34$	1
$m(Ba(OH)_2) = 171.34 \times 6.79489 \times 10^{-4} = 0.116$ g	1
Total	**6**

(b)   Discuss the effect, if any, on the mass of barium hydroxide required if the original solution
       were sulfuric acid.   (2 marks)

Description	Marks
pH = 1.52 or $[H^+] = 0.0302$ mol L^{-1} for either acid	1
So irrespective of what acid the same mass of base is required	1
Total	**2**

End of section two

Section Three: Extended answer (88 Marks)

(a) Determine the concentration of $FeSCN^{2+}(aq)$ present at equilibrium. (1 mark)

Description	Marks
0.002 mol L^{-1}	**1**
Total	**1**

(b) Sketch a graph, including all relevant species, showing the establishment of equilibrium, from Time 0 where the reactants were mixed, to Time E1, where equilibrium was established and maintained. (5 marks)

Description	Marks
$Fe^{3+}(aq)$ concentration decreases from 0.01 to 0.008 mol L^{-1}	**1**
$SCN^{-}(aq)$ concentration decreases from 0.006 to 0.004 mol L^{-1}	**1**
$FeSCN^{2+}(aq)$ concentration increases from 0 to 0.002 mol L^{-1}	**1**
Horizontal lines from E1 onwards	**1**
Labels on each of the three curves	**1**
Total	**5**

Example of a five mark response
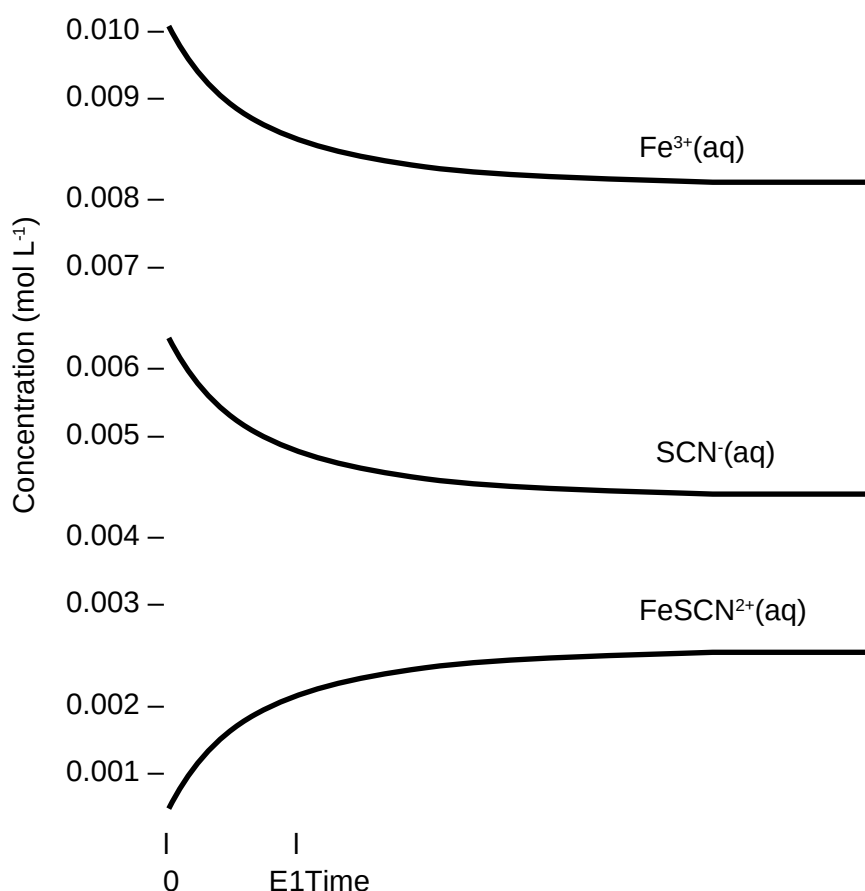
(c) Justify these results by using Le Chatelier's principle and making reference to any appropriate equations provided. (6 marks)

Description	Marks
Addition of H$_3$O$^+$:	
The H$_3$O$^+$(aq) added will react with SCN$^-$(aq) as shown in equation (ii)	**1**
The SCN$^-$(aq) concentration will therefore be lowered	**1**
The original equilibrium will therefore shift left to increase the concentration of SCN$^-$(aq)	**1**
Addition of OH$^-$:	
The OH$^-$(aq) added will react with Fe^{3+}(aq) as shown in equation (iii)	**1**
The Fe^{3+}(aq) concentration will therefore be lowered	**1**
The original equilibrium will therefore shift left to increase the concentration of Fe^{3+}(aq)	**1**
Total	**6**

(d) Describe the observation that would have distinguished between the addition of acid and base to the equilibrium system. (1 mark)

Description	Marks
Addition of OH$^-$(aq) would cause a pale brown precipitate to form	1
Total	**1**

(e) Explain, in terms of reaction rates, the effect this would have on the equilibrium position. (4 marks)

Description	Marks
Adding KF(aq) would (increase the concentration of F$^-$(aq) which will react with, and) lower the concentration of Fe^{3+}(aq)	1
This would decrease both the forward and reverse reaction rates (due to a decreased frequency of collisions)	1
The reverse reaction rate would not decrease by as much as the forward reaction rate **or** The forward reaction rate would decrease more, relative to the reverse reaction rate	1
This would result in a shift to the left / the reverse reaction being favoured	1
Total	**4**

Question 36   **(14 marks)**

(a)   Explain why the pH at the first equivalence point is acidic, whilst the pH at the second equivalence point is basic. Include relevant chemical equations in your answer.

(4 marks)

Description	Marks
At the first equivalence point:	
The salt produced (NaH_2PO_4) is acidic due to the presence / hydrolysis of $H_2PO_4^-$(aq) ions (which results in an excess of H_3O^+ ions)	**1**
$H_2PO_4^-$(aq) + H_2O(l) → HPO_4^{2-}(aq) + H_3O^+(aq)	**1**
At the second equivalence point:	
The salt produced (Na_2HPO_4) is basic due to the presence / hydrolysis of HPO_4^{2-}(aq) ions (which results in an excess of OH^- ions)	**1**
HPO_4^{2-}(aq) + H_2O(l) → $H_2PO_4^-$(aq) + OH^-(aq)	**1**
Total	**4**

(b)   Suggest one practical reason a pH meter is used to detect the equivalence point, instead of the indicator phenolphthalein.   (1 mark)

Description	Marks
The colour of the Coca-Cola would obscure the indicator colour	**1**
Total	**1**

(c)   Calculate the milligrams of phosphorus present in a 375 mL can of Coca-Cola.   (6 marks)

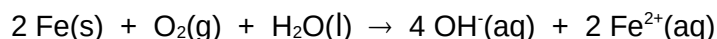| Description		Marks
n(NaOH)	**= 0.1005 x 0.01665** **= 0.0016733 mol**	**1**
n(H_3PO_4)	**= 0.0016733 / 2** **= 0.00083666 mol** **= n(H_3PO_4 in 150 mL Coca-Cola)**	**1**
	= n(P in 150 mL Coca-Cola)	**1**
n(P in 375 mL can)	**= 0.00083666 x (375 / 150)** **= 0.00209165 mol**	**1**
m(P)	**= 0.00209165 x 30.97** **= 0.064778 g**	**1**
	= 64.78 mg	**1**
	Total	**6**

(d)   Classify this error as random or systematic. Justify your choice and state the likely effect this would have on the students' calculated phosphorus content.   (3 marks)

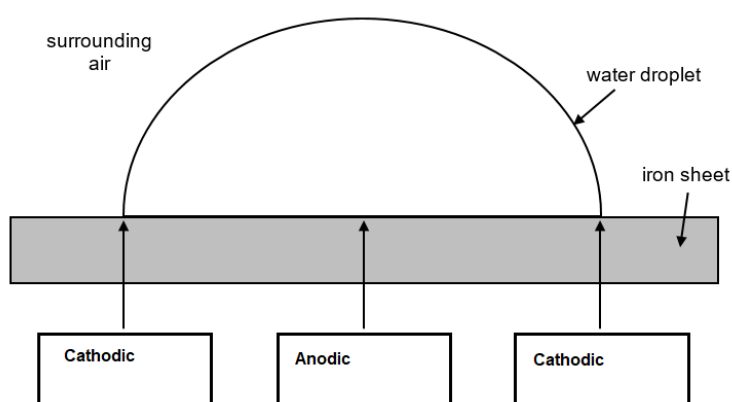| Description	Marks
Systematic	**1**
This error would result in consistently higher titre values	**1**
The calculated concentration of P would be greater than the true value	**1**
Total	**3**

Question 37 (18 marks)

Iron is used widely in modern society, in structures such as bridges and buildings, in reinforced concrete as well as piping, and to manufacture cars and ships. The corrosion of iron to form rust is a costly and potentially dangerous problem, and a great deal of money is spent trying to prevent, reduce and repair the damage caused by the corrosion of iron.

The corrosion of iron to form rust involves a sequence of reactions. The process generally begins when iron comes into contact with water and oxygen. The overall equation for the initial redox reaction involved in the corrosion of iron can be represented by the following chemical equation.

$$2\ Fe(s)\ +\ O_2(g)\ +\ H_2O(l)\ \rightarrow\ 4\ OH^-(aq)\ +\ 2\ Fe^{2+}(aq)$$

(a) The diagram below shows a close-up view of a water droplet on a sheet of iron.

Description	Marks
Cation (Fe^{2+} label and direction)	**1**
Anion (OH$^-$ label and direction)	**1**
Total	**2**

Example of a two mark response

Note: if ion flow is only labelled on one 'side' of the water droplet, allocate full marks

(b)   Demonstrate that this reaction is a redox process, using oxidation numbers to support your answer.   (2 marks)

Description	Marks
Oxidation of iron atoms from (0) in Fe to (+2) in Fe^{2+}	**1**
Reduction of oxygen atoms from (0) in O_2 to (-2) in OH^-	**1**
	Total	**2**

Consider the following statement made by a student in response to a question on corrosion.

'Corrosion of iron is a very slow process so the reaction will have a small equilibrium constant.'

(c)   Comment on this statement by discussing both rate of reaction and equilibrium. (4 marks)

Description	Marks
As corrosion is a slow process its rate of reaction can be said to be low	**1**
This means it will take a long time to come to equilibrium	**1**
(The equilibrium constant is [products]/[reactants]) a small K implies the reactants are favoured	**1**
This is not necessarily the case as the forward reaction (forming rust) may be largely favoured giving a large value for K	**1**
	Total	**4**

The next step in the reaction sequence to form rust, involves the formation of a precipitate.

(d)   Write a balanced ionic equation for this step.   (1 mark)

Description	Marks
$Fe^{2+}(aq) + 2\,OH^-(aq) \rightarrow Fe(OH)_2(s)$	**1**
	Total	**1**

The product of this precipitation reaction is further oxidised to solid iron(III) hydroxide, which then dehydrates to form orange-brown rust, $Fe_2O_3.H_2O(s)$. This is illustrated in the chemical equation below.

$$2\,Fe(OH)_3(s) \rightarrow Fe_2O_3.H_2O(s) + 2\,H_2O(l)$$
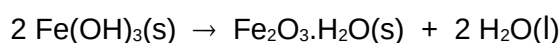
The mass of a sample of iron sheet was recorded. After a period of time, rust formed on the surface of the iron. All traces of the rust were then scraped off, and the new mass of the iron sheet was recorded. The results are shown in the table below.

Initial mass of iron (g)	84.2 g
Final mass of iron (g)	77.1 g

(e) Calculate the volume of $O_2(g)$ that would have reacted to produce this rust. The partial pressure of $O_2(g)$ in air is 21.2 kPa and the temperature of the air was 19.3 °C. State your answer to the appropriate number of significant figures. (5 marks)

Description		Marks
m(Fe reacted)	= 84.2 – 77.1 = 7.1 g	1
n(Fe)	= 7.1 / 55.85 = 0.12713 mol	1
n(O_2)	= 0.12713 / 2 = 0.063563 mol	1
V(O_2)	= (0.063563 x 8.314 x 292.45) / 21.2 = 7.29006 L	1
	= 7.29 L (3 SF)	1
	Total	5

(f) Calculate the maximum mass of rust, $Fe_2O_3.H_2O(s)$, that would have formed from this corrosion. (2 marks)

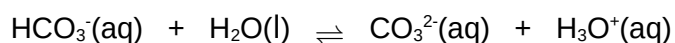| Description		Marks
n($Fe_2O_3.H_2O$)	= 0.12713 / 2 = 0.063563 mol	1
m($Fe_2O_3.H_2O$)	= 0.063563 x 177.716 = 11.3 g	1
	Total	2

This experiment was repeated with a galvanised iron sheet (i.e. an iron sheet coated in zinc), which was exposed to identical conditions, for the same period of time. The galvanised iron sheet showed no signs of rust.

(g) Explain these observations. (2 marks)

Description	Marks
The zinc coating acts as a sacrificial anode	1
This is because zinc has a higher oxidation potential / is more reactive than iron	1
Therefore the zinc coating will be preferentially oxidised	1
The iron is thus protected, and no evidence of corrosion is seen (until all of the Zn coating has been oxidised)	1
Any two Total	2

Question 38 **(20 marks)**

The buffering capacity of seawater results from the presence of hydrogencarbonate, HCO_3^-(aq) and carbonate, CO_3^{2-}(aq) ions. The chemical equation for this buffer is given below.

$$HCO_3^-(aq) \ + \ H_2O(l) \ \rightleftharpoons \ CO_3^{2-}(aq) \ + \ H_3O^+(aq)$$

(a) Define a buffer. (2 marks)

Description	Marks
A solution containing a weak conjugate acid-base pair,	**1**
that can resist a change in pH when small amounts of acid or base are added to it	**1**
Total	**2**

(b) Describe how the large increase in atmospheric CO_2(g) caused by human activity, results in a higher H_3O^+(aq) concentration in seawater. (Note: chemical equations are **not** required in your answer). (3 marks)

Description	Marks
Some of the excess atmospheric CO_2(g) dissolves into seawater,	**1**
which then forms carbonic acid	**1**
Carbonic acid then hydrolyses / ionises to produce H_3O^+(aq)	**1**
Total	**3**

(c) Justify, using Le Chatelier's principle, how the hydrogencarbonate / carbonate buffer system in seawater responds to this increase in H_3O^+(aq). (2 marks)
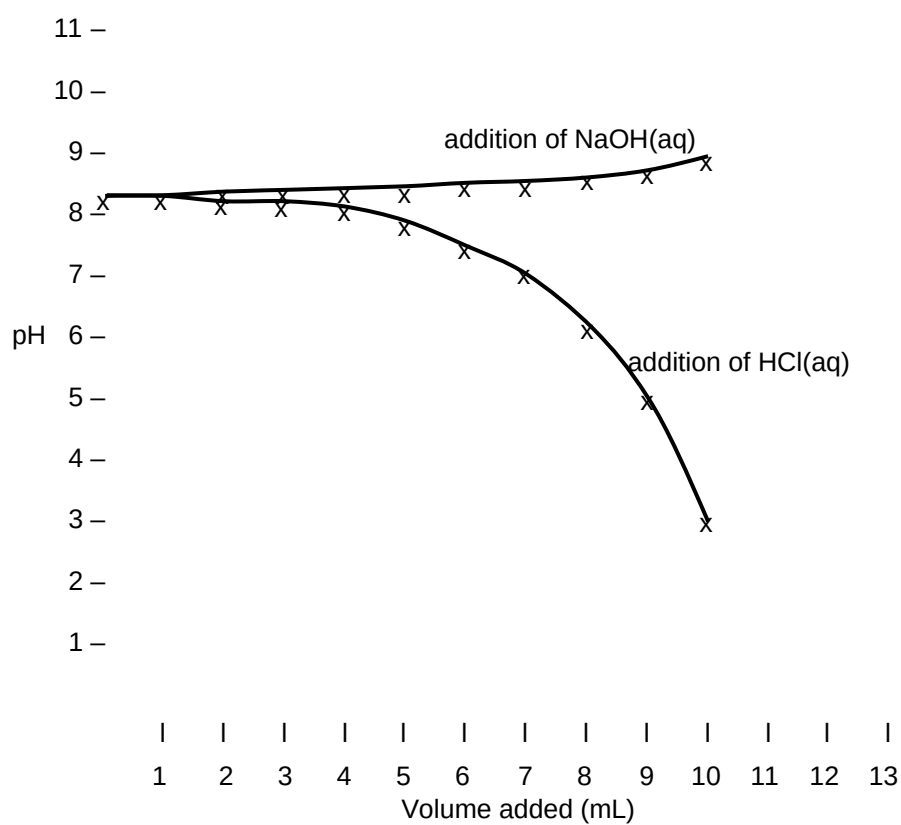
Description	Marks
The increase in H_3O^+(aq) shifts the equilibrium to the left	**1**
This will partially counteract the change by decreasing the H_3O^+(aq) concentration / using up some of the extra H_3O^+(aq)	**1**
Total	**2**

(d) Plot this data on the same set of axes, using the grid below. (5 marks)

Description	Marks
x-axis label and scale	1
y-axis label and scale	1
Points and curve for addition of HCl(aq)	1
Points and curve for addition of NaOH(aq)	1
Labels on each curve	1
Total	5

Example of a five mark response

(e)   Does seawater contain a higher concentration of $HCO_3^-(aq)$ or $CO_3^{2-}(aq)$? Justify your
        answer, by referring to the data collected in this investigation.   (4 marks)

Description	Marks
Higher concentration of $HCO_3^-(aq)$	1
The seawater has a higher buffering capacity for the addition of $OH^-(aq)$	1
This is shown by the seawater resisting a pH change upon addition of a greater amount of $OH^-(aq)$	1
Therefore there must be a higher concentration of the conjugate acid species present (relative to the conjugate base species)	1
Total	4

(f)   State two (2) negative consequences associated with the cuttlefish not being able to
        form its internal calcium carbonate shell.   (2 marks)

Description	Marks
Any **two** of the following (or other relevant answers):	
• may disrupt the food web • species may be unable to reproduce • species may become endangered / extinct • reduced biodiversity of ecosystem (if endangered / extinct)	2
Total	2

(g)   Suggest two (2) ways humans can reduce their production of $CO_2(g)$.   (2 marks)

Description	Marks
Any two of the following (or other relevant answers):	
• reduce reliance on fossil fuels • reduce car use / take public transport / ride bikes • decrease use of electricity • reduce consumption of meat • reduce deforestation • increase use of biofuels / renewable sources of energy	2
Total	2

Question 40 **(19 marks)**

Gold is a precious metal that humankind has used for thousands of years. Over the centuries there have been many methods used to extract gold from its ore. Whilst it is a relatively unreactive metal, it does dissolve in alkaline solutions of cyanide. This discovery, in 1783, lead to the development of the 'gold cyanidation' process, which is widely used today.

In the extraction of gold, the ore is first ground and crushed. Water and sodium cyanide solution, NaCN(aq), are then added to form a slurry. This mixture is then left for 16 - 48 hours with a stream of oxygen gas passing through the mixture. During this time 'gold leaching' occurs. This process results in the gold being oxidised to the (+1) oxidation state and dissolving into solution to form the aurocyanide ion.

This process can be represented by the 'Elsner equation'.

$$4\ Au(s)\ +\ 8\ CN^-(aq)\ +\ O_2(g)\ +\ 2\ H_2O(l)\ \rightarrow\ 4\ Au(CN)_2^-(aq)\ +\ 4\ OH^-(aq)$$
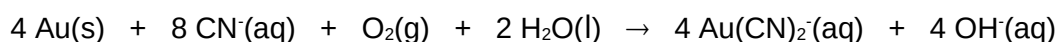
A sample of gold-bearing ore was crushed and placed in a tank, along with 25 kL of leaching solution. The initial concentration of NaCN(aq) in the leach solution was 0.478 g L^{-1}. After 48 hours, this had fallen to 0.083 g L^{-1}.

Calculate the mass of gold that was leached into solution. (6 marks)

Description		Marks
m(NaCN initial)	**= 0.478 x 25000** **= 11950 g**	**1**
m(NaCN final)	**= 0.083 x 25000** **= 2075 g**	**1**
m(NaCN reacted)	**= 11950 - 2075** **= 9875 g**	**1**
n(NaCN)	**= 9875 / 49.01** **= 201.4895 mol**	**1**
n(Au)	**= (1/2) x 201.4895** **= 100.7447 mol**	**1**
m(Au)	**= 100.7447 x 197** **= 19847 g (2.0 x 10^4 g)**	**1**
	Total	**6**

(b) Calculate the final pH of the leaching solution. (You may assume that only the $OH^-(aq)$ ions produced are contributing to pH). (4 marks)

Description		Marks
n(OH⁻)	**= 100.7447 mol**	**1**
c(OH⁻)	**= 100.7447 / 25000** **= 0.0040298 mol L^{-1}**	**1**
[H⁺]	**= (1.0 x 10^{-14}) / 0.0040298** **= 2.4815 x 10^{-12} mol L^{-1}**	**1**
pH	**= - log (2.4815 x 10^{-12})** **= 11.6 (12)**	**1**
	Total	**4**

Alternate working:
pOH   = - log (0.0040298)
**   = 2.3947**
pH   = 14 - 2.3947
**   = 11.6   (12)**

(c)   State the oxidant and the reductant in this process.   (2 marks)

Description	Marks
Oxidant: $Au(CN)_2^-$	1
Reductant: Zn	1
Total	2

(d)   Explain, in terms of the collision theory, why zinc **dust** is used to precipitate the gold out of solution.   (3 marks)

Description	Marks
The dust has a high surface area / high state of subdivision	1
This results in an increased frequency of collision,	1
and therefore a faster reaction rate	1
Total	3

(e)   Explain how this would allow separation of the two metals to occur. Use data from your standard reduction potential table to support your answer.   (4 marks)

Description	Marks
The cell potential / EMF for the reaction between Zn and H^+ is positive (+ 0.76 V)	1
The cell potential / EMF for the reaction between Au and H^+ is negative (- 1.50 V)	1
Therefore the reaction between Zn and the acid is spontaneous / the reaction between Au and the acid is non-spontaneous	1
This will result in the Zn dissolving in the acid, leaving behind solid Au (which can thus be separated)	1
Total	4

End of questions