SHENTON COLLEGE

CHEMISTRY

SEMESTER 1

2018

Name: _____

Teacher: _____

TIME ALLOWED FOR THIS PAPER
Reading time before commencing work: ten minutes
Working time for the paper: two and a half hours

MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER

To be provided by the supervisor:
This Question/Answer Booklet
Multiple-choice Answer Sheet
Chemistry Data Book

To be provided by the candidate:
Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, eraser, correction tape/fluid, ruler, highlighters

Special items: up to three non-programmable calculators approved for use in the WACE examinations

IMPORTANT NOTE TO CANDIDATES
No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Structure of this paper

Section	Number of	Number of	Suggested	Marks	Percentage of

	questions available	questions to be answered	working time (minutes)	available	exam
Section One: Multiple-choice	20	20	40	/40	/25
Section Two: Short answer	7	7	50	/60	/35
Section Three: Extended answer	5	5	60	/70	/40
					/100

Instructions to candidates

1. Answer the questions according to the following instructions.

   Section One: Answer all questions on the separate Multiple-choice Answer Sheet provided. For each questions shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

   Sections Two and Three: Write your answers in this Question/Answer Booklet.

2. When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.

3. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

4. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.
   - Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
   - Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Section One: Multiple-choice **25% (40 marks)**

This section has **20** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided. For each question, shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time: 50 minutes.

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1. Which of the following lists substances that are commonly used as an oxidising agent (oxidant) and a reducing agent (reductant)?

	Oxidising agent		**Reducing agent**
(a)	$Cr_2O_7^{2-}$	MnO_4^-	
(b)	MnO_4^-		Cl^-
(c)	Cl_2		$H_2C_2O_4$
(d)	Mg		$Cr_2O_7^{2-}$

2. The following equation represents the autoionisation of water.

$$2\ H_2O(l) + \text{heat} \rightleftharpoons H_3O^+(aq) + OH^-(aq)$$

For pure water at 50 ˚C, which of the following is **correct**?

(a) The H_3O^+ concentration is greater than 1.0×10^{-7} mol L^{-1}.
(b) The OH^- concentration is less than 1.0×10^{-7} mol L^{-1}.
(c) The pH of water is greater than 7.
(d) The K_w of water is less than 1.0×10^{-14}.

3. The combustion of ethanol can be represented by the following equation;

$$C_2H_5OH(l) + 3\ O_2(g) \rightarrow 2\ CO_2(g) + 3\ H_2O(g)$$

Which of the following statements is **correct** regarding this combustion equation?

(a) Oxygen gas is the reductant.
(b) The oxidation number of carbon increases.
(c) The oxidation number of hydrogen decreases.
(d) Ethanol is reduced.

4. When this <u>half-equation</u> is correctly balanced, what is the coefficient of $H^+(aq)$?

$$ClO_3^-(aq) + H^+(aq) \rightarrow Cl_2(g) + H_2O(l)$$

(a) 4
(b) 6
(c) 8
(d) 12

5. A sample of barium sulfate powder is added to a beaker containing distilled water and stirred. The following chemical reactions occur;

① $BaSO_4(s) \rightleftharpoons Ba^{2+}(aq) + SO_4^{2-}(aq)$

② $SO_4^{2-}(aq) + H_2O(l) \rightleftharpoons HSO_4^-(aq) + OH^-(aq)$

If a few drops of $HNO_3(aq)$ was added to the beaker, which of the following statements are **correct**?

(i) Equilibrium ① shifts to the left.
(ii) Equilibrium ② shifts to the right.
(iii) The pH of the solution would increase.
(iv) The amount of $BaSO_4(s)$ present would decrease.
(v) The concentration of $Ba^{2+}(aq)$ in the solution would increase.

(a) (i), (iii) and (v) only
(b) (ii), (iv), and (v) only
(c) (ii), (iii) and (iv) only
(d) (i), (ii) and (v) only

6. Which of the following solutions **could** be safely stored in the metal container stated?

(a) Copper(II) nitrate in a tin container.
(b) Potassium permanganate in a copper container.
(c) Nickel chloride in a lead container.
(d) Cobalt sulfate in an iron container.

7. For a sample of 0.1 mol L^{-1} $H_3PO_4(aq)$, which of the following is **not** correct?

(a) $[H_3PO_4] > [PO_4^{3-}]$
(b) $[H_3O^+] > [H_2PO_4^-]$
(c) $[H_2PO_4^-] > [HPO_4^{2-}]$
(d) $[H_3O^+] > [H_3PO_4]$

Questions 8, 9 and 10 relate to the following information.

The equilibrium shown below represents the endothermic decomposition of nitrogen tribromide into nitrogen and bromine vapours. Nitrogen tribromide and nitrogen are colourless gases, whereas bromine is a red vapour.

$$2\ NBr_3(g) \rightleftharpoons N_2(g) + 3\ Br_2(g)$$

If some nitrogen tribromide is injected into an empty flask;

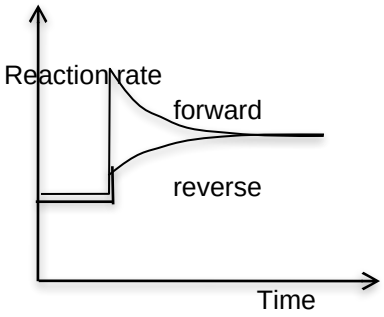
8. Which of the following is **not necessarily true** of the system once equilibrium is established?

(a) The pressure of the system would remain constant.
(b) The partial pressure of NBr_3 would remain constant.
(c) The partial pressure of N_2 would be half that of NBr_3.
(d) The partial pressure of Br_2 would be three times that of N_2.

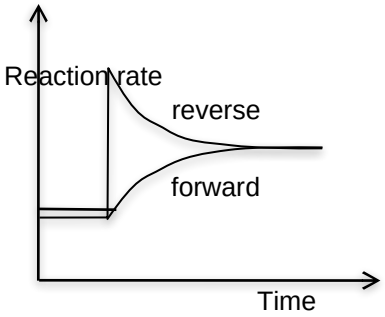
Once equilibrium was established, the temperature of the system was increased.

9. Which of the following graphs **best** shows the effect of this temperature increase on reaction rate?

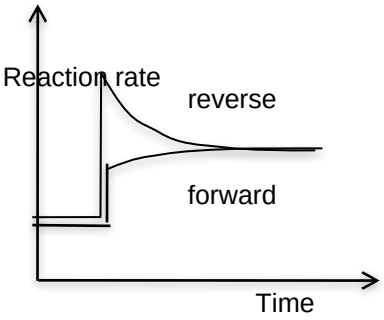
(a)



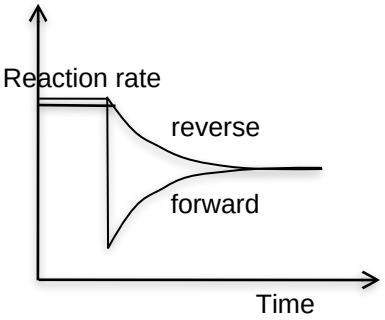
(b)



(c)



(d)



Once the system had re-established equilibrium, some $N_2(g)$ was removed.

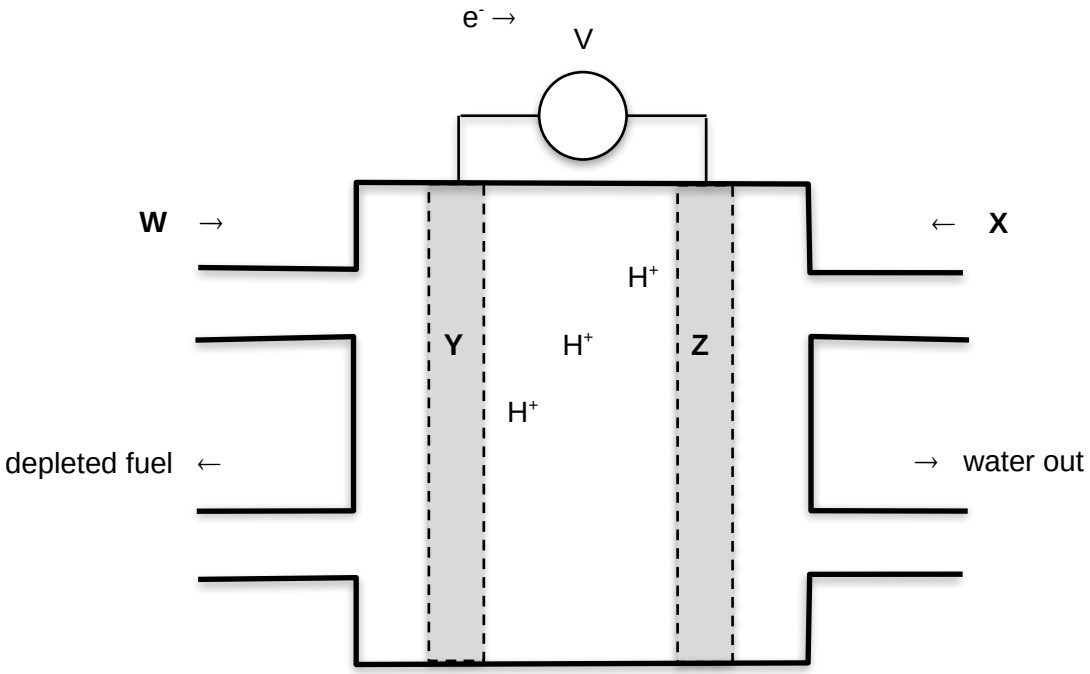
10. Which of the following correctly states the effect of N_2 removal on the equilibrium position, as well as the corresponding observations?

	Equilibrium position	**Observations**
(a)	favour reverse	darker red
(b)	favour reverse	lighter red
(c)	favour forward	darker red
(d)	favour forward	lighter red

See Next Page

Questions 11 and 12 refer to the information below.

The incomplete diagram below represents the phosphoric acid fuel cell (PAFC). As with other variations of the hydrogen / oxygen fuel cell, the only overall chemical product is water.



11. Which of the following **correctly** identifies the letters W, X, Y and Z in the diagram above?

	W	**X**	**Y**	**Z**
(a)	H_2	O_2	anode	cathode
(b)	O_2	H_2	anode	cathode
(c)	H_2	O_2	cathode	anode
(d)	O_2	H_2	cathode	anode

12. Which of the following statements regarding fuel cells is **correct**?

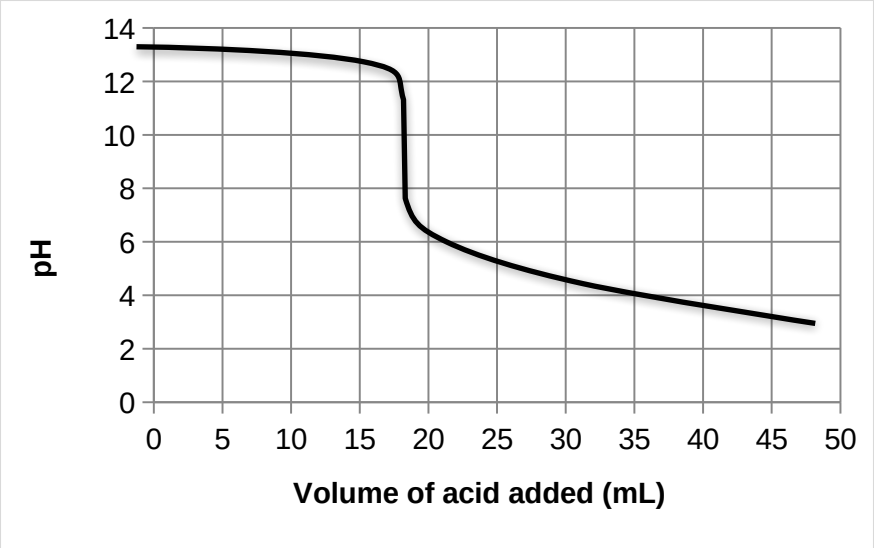
(a) Fuel cells are a type of galvanic cell.
(b) Fuel cells are a type of electrolytic cell.
(c) Fuel cells are a type of primary cell.
(d) Fuel cells are a type of secondary cell.

13. If the equilibrium constant (K) value of a particular gaseous equilibrium system increases, which of the following **must be true**?

(a) The pressure has been increased.
(b) The temperature has been increased.
(c) The concentration of reactants has been increased.
(d) The ratio of product concentration to reactant concentration has been increased.

Questions 14, 15 and 16 relate to the titration data below.

A teacher accurately performed a particular acid-base titration and, using a pH meter, was able to graph the titration curve shown below.



Four groups of chemistry students (W, X, Y, Z) then attempted to replicate the same titration. Each group performed four trials, and their titre values are shown in the table below.

	Trial 1	Trial 2	Trial 3	Trial 4
W	16.10 mL	16.05 mL	16.00 mL	16.05 mL
X	19.40 mL	19.35 mL	19.45 mL	19.40 mL
Y	19.50 mL	19.20 mL	19.30 mL	19.6 mL
Z	35.20 mL	35.25 mL	35.15 mL	35.25 mL

14. Which group of students has performed the titration **most accurately**?

(a) W
(b) X
(c) Y
(d) Z

15. Which group of students is **most likely** to have incorrectly used methyl orange indicator?

(a) W
(b) X
(c) Y
(d) Z

16. Which experimental set up was used for this titration?

	Burette solution	**Conical flask solution**
(a)	KOH(aq)	CH_3COOH(aq)
(b)	CH_3COOH(aq)	KOH(aq)
(c)	NH_3(aq)	HCl(aq)
(d)	HCl(aq)	NH_3(aq)

17. In which of the following compounds does sulfur have an oxidation number of +4?

(i) SO_2
(ii) H_2SO_4
(iii) H_2S
(iv) H_2SO_3
(v) $Na_2S_2O_3$

(a) (i) only
(b) (iii) only
(c) (i) and (iv) only
(d) (ii) and (v) only

18. Which of the following is **not** a redox reaction?

(a) $HCrO_4^- + 3\ H^+ + NO \rightarrow Cr^{3+} + 2\ H_2O + NO_3^-$
(b) $Cr_2O_7^{2-} + 2\ H_2O + NH_4^+ \rightarrow 2\ HCrO_4^- + NH_3 + H_3O^+$
(c) $Cr_2O_7^{2-} + 5\ H^+ + 3\ HNO_2 \rightarrow 2\ Cr^{3+} + 4\ H_2O + 3\ NO_3^-$
(d) $HCrO_4^- + H^+ + 3\ N_2O \rightarrow Cr + H_2O + 6\ NO$

Questions 19 and 20 relate to the following information.

A chemist mixed 0.1 mol L^{-1} solutions of a weak, monoprotic acid and its sodium salt together in a beaker. The conjugate species formed a buffer as shown below;

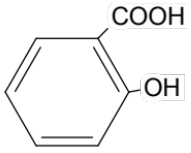
$$\text{weak acid(aq)} + H_2O(l) \rightleftharpoons \text{conjugate base(aq)} + H_3O^+(aq)$$

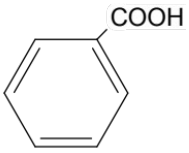
19. If a few drops of HCl(aq) are added to this system, which is **correct**?

(a) The pH falls quickly.
(b) The concentration of the weak acid equals the concentration of the conjugate base.
(c) The concentration of the weak acid increases.
(d) The concentration of the weak acid remains fairly constant until the buffering capacity is exceeded.

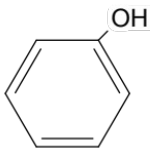
20. Which of the following pairs of substances, when dissolved in water, could produce a buffer matching the above description?

(a) $KHCO_3$ and K_2CO_3

(b) 

and


(c) HNO_3 and $NaNO_3$

(d) 

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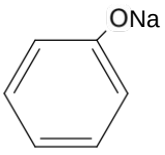

End of Section One

Section Two: Short answer **35% (60 marks)**

This section has **7** questions. Answer **all** questions. Write your answers in the spaces provided.

When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.

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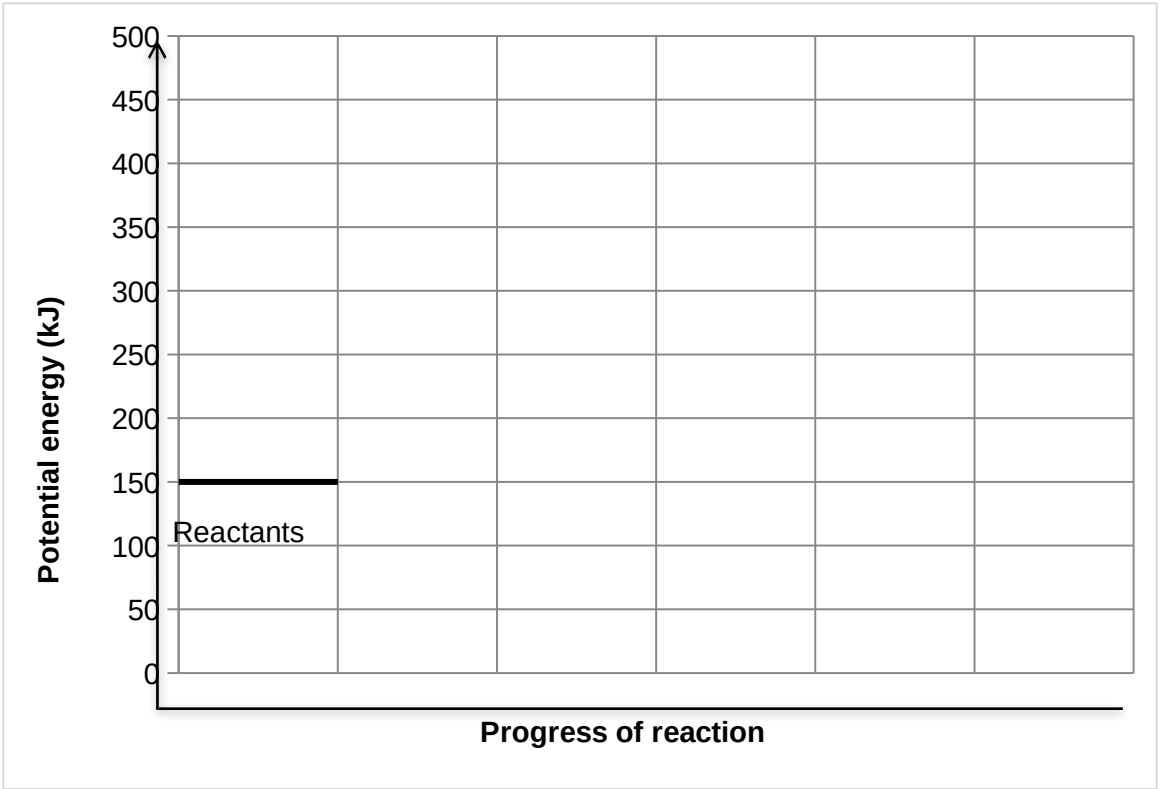
Suggested working time: 60 minutes.

Question 21 **(10 marks)**

The first part of an energy profile diagram has been sketched on the axes below.



If the activation energy of the **reverse** reaction is 70 kJ and the heat of reaction (enthalpy change) of the **forward** reaction is 210 kJ mol^{-1};

(a) Complete the energy profile diagram above. Label the products and the transition state (activated complex). (3 marks)

If a catalyst was added at the start of the reaction;

(b) Which of the following is the **most likely** new value of the activation energy for the **forward** reaction? (circle your answer) (1 mark)

180 kJ 230 kJ 290 kJ

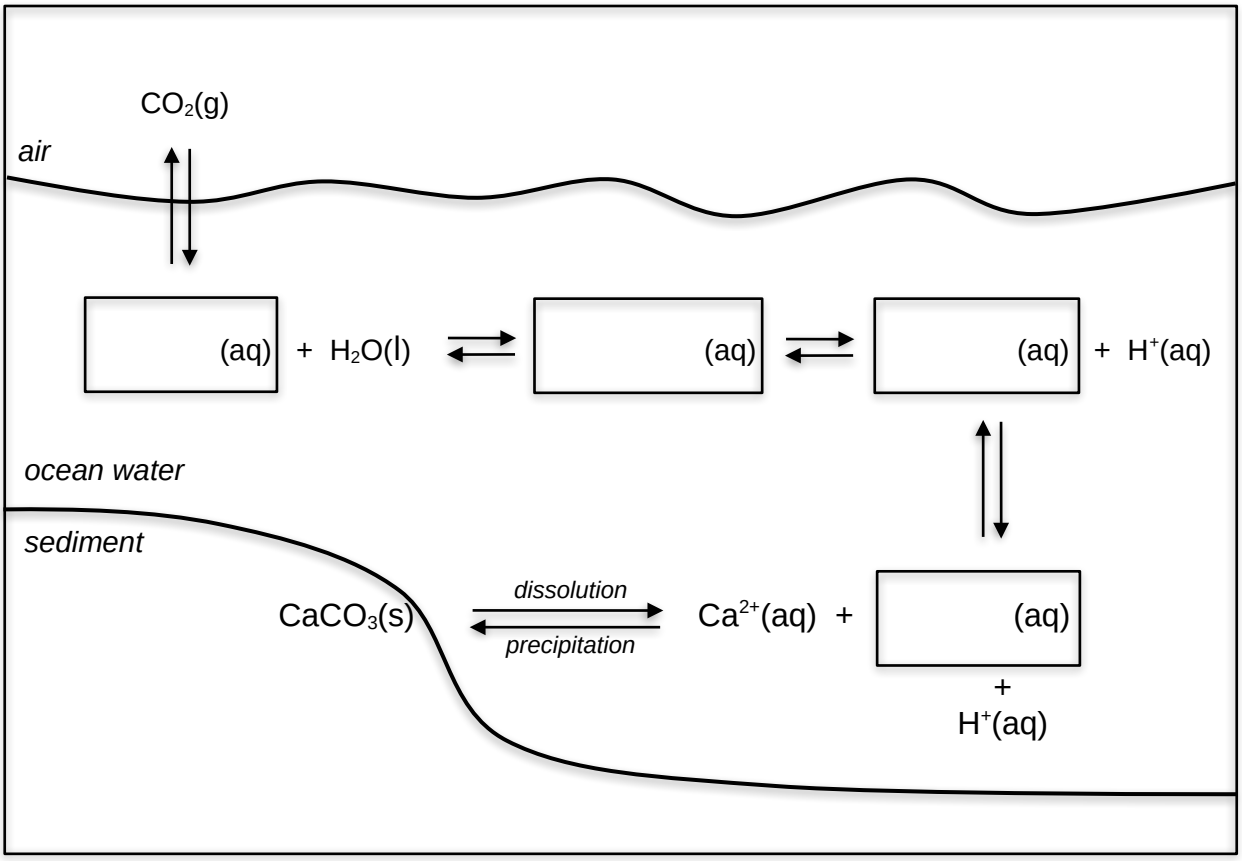
If the temperature of this system was decreased;

(c) Explain, in terms of the collision theory, the effect this would have on the rate of reaction. (3 marks)

(d) Assuming this is a reversible reaction, what effect would this temperature decrease have on the value of the equilibrium constant, K? Justify your answer. (3 marks)

Question 22 **(8 marks)**

Examine the diagram below, which shows some of the relevant equations involved in ocean equilibria, specifically the role of carbon-containing species.

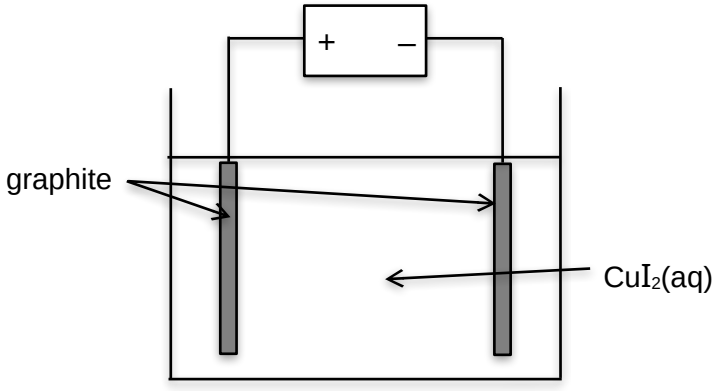


(a) Complete the equilibrium equations on the diagram above, by writing the chemical formula of the four (4) missing carbon-containing species in the boxes. (4 marks)

(b) Explain how higher atmospheric carbon dioxide levels cause a decrease in ocean pH, whereas the calcium carbonate present in sediment can counteract this to increase ocean pH. (4 marks)

Question 23 **(8 marks)**

An electrolytic cell is set up as shown below. The electrolyte is aqueous copper(II) iodide and both electrodes are made from graphite. As the cell runs, copper metal and iodine are produced.



(a) Indicate the direction of electron flow and cation flow on the diagram above. (2 marks)

(b) Write half-equations to illustrate the reactions occurring at each electrode. (2 marks)

cathode	
anode	

(c) Tick **all** of the **observations** that are **correct** for this cell as it continues to run. (2 marks)

- copper metal forms at the cathode
- a silver metal forms at the negative electrode
- a salmon pink metal forms at the anode
- the electrolyte becomes paler blue
- a brown solution forms around the positive electrode

(d) When aqueous copper(II) **chloride** is electrolysed, oxygen gas forms instead of chlorine gas. Explain why this occurs. (2 marks)

Question 24 **(10 marks)**

The 'etching' of silicon is performed in the production of semiconductor materials, which are used in all forms of modern technology, such as mobile phones and computers. This etching can be achieved using the reversible chemical reaction below.

$$Si(s) + 4\,HF(g) \rightleftharpoons SiF_4(g) + 2\,H_2(g) + heat$$

(a) Write an equilibrium constant (K) expression for this reaction. (1 mark)

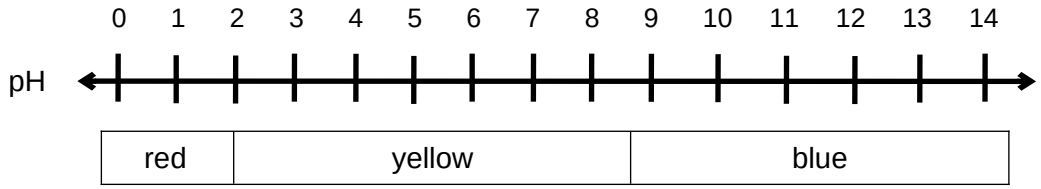
(b) Complete the following table, for each of the imposed changes stated. In each case, state the immediate effect on the forward reaction rate and the shift in the new equilibrium position. (6 marks)

	Forward reaction rate (increase, decrease, no change)	Equilibrium position (left, right, no change)
Increase in total volume of the system		
Removal of some $H_2(g)$ from system		
Increase in temperature of the system		

(c) Rather than blocks or cubes of silicon (Si), the silicon used in etching is in the form of extremely thin pieces called 'wafers'. Explain, in terms of the collision theory, what effect this has on both the forward reaction rate and yield of the reaction. (3 marks)

Question 25 **(10 marks)**

Thymol blue is an indicator that has two distinct colour changes and displays three different colours over the pH range 0 to 14, as shown in the diagram below.



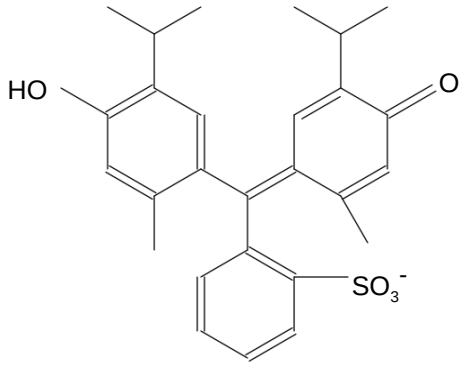
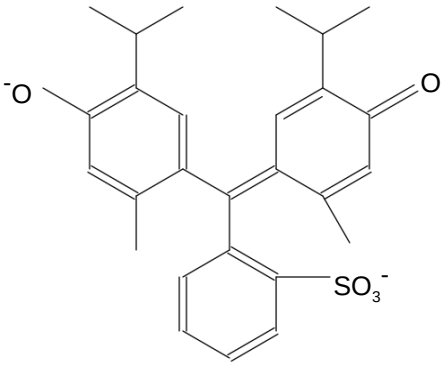
A few drops of thymol blue were added to the following 0.2 mol L^{-1} solutions;

- $HNO_3(aq)$
- $Mg(NO_3)_2(aq)$
- $NH_4NO_3(aq)$
- $KHCO_3(aq)$

(a) Which of these substances is most likely to turn blue? Use an equation to support your answer. (2 marks)

(b) State two (2) solutions that **could not** be distinguished by adding thymol blue. Justify your answer using appropriate chemical equations. (4 marks)

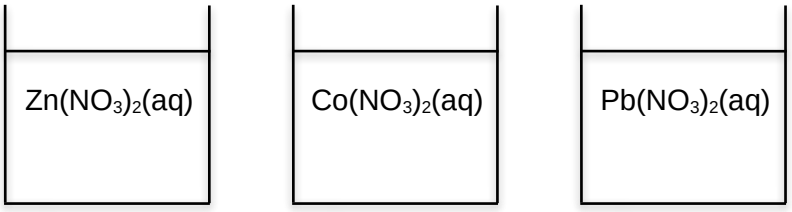
(c) Two forms of thymol blue, at different pH, are shown in the table below. Complete the table, by writing which structure is blue in colour and which is yellow. (1 mark)

Thymol blue structure		
Colour (blue or yellow)		

(d) Justify your answer to (c). Include a brief description of how indicators function (i.e. how they are able to change colour). (3 marks)

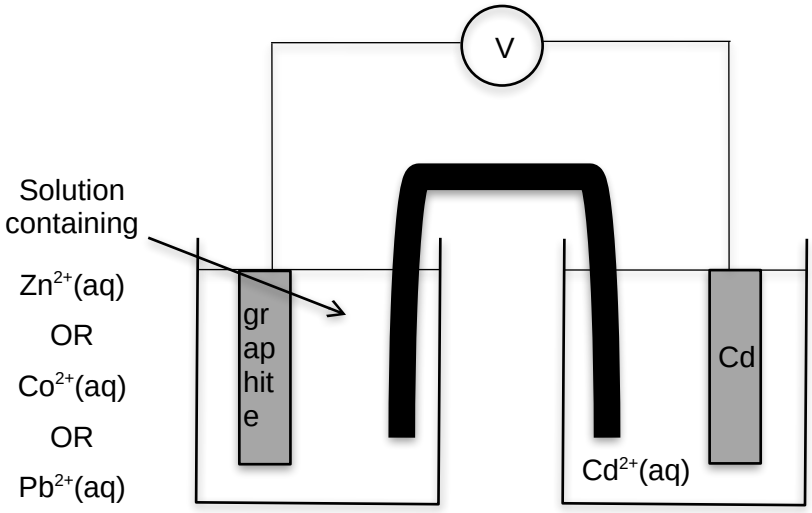
Question 26 **(10 marks)**

Three beakers were prepared as shown below, each containing a 1.0 mol L^{-1} solution of a different aqueous metallic salt.



(a) Which of these is the strongest oxidising agent (oxidant)? Justify your answer. (2 marks)

A graphite rod was placed in each of the beakers shown above. One by one, they were connected to a $Cd(s)/Cd^{2+}(aq)$ half-cell and the voltage of each combination was measured. The following diagram represents the experimental set up. Assume standard conditions for all half-cells.



One of the half-cells would **not** produce a voltage when connected to the $Cd(s)/Cd^{2+}(aq)$ half-cell.

(b) Name this half-cell and explain why no voltage is produced. (2 marks)

The remaining half-cells **would** produce a voltage when connected to the Cd(s)/Cd^{2+}(aq) half-cell. For these examples;

(c) Indicate the direction of electron flow and anion flow on the diagram above. (2 marks)

(d) Is the Cd(s) the anode or the cathode? (1 mark)

(e) Which combination of half-cells would produce the highest voltage? Calculate the EMF produced by this combination. (2 marks)

(f) What is the function of the graphite electrode in the half-cells? (1 mark)

Question 27 **(4 marks)**

The Arrhenius theory of acids and bases introduced the relationship between acid behaviour and $H^+(aq)$ ions.

The Bronsted-Lowry theory of acids and bases introduced the concept of the hydronium ion, $H_3O^+(aq)$, as well as conjugate acid-base pairs.

(c) Explain what the '$H_3O^+(aq)$' notation is referring to and why it is often used in preference to the '$H^+(aq)$' notation. (2 marks)

(d) Label and link the conjugate acid-base pairs in the equation below. (2 marks)

$$NO_2^-(aq) + HSO_4^-(aq) \rightleftharpoons SO_4^{2-}(aq) + HNO_2(aq)$$

End of Section Two

Section Three: Extended answer **40% (70 marks)**

This section contains **five (5)** questions. You must answer **all** questions. Write your answers in the spaces provided below.

Where questions require an explanation and/or description, marks are awarded for the relevant chemical content and also for coherence and clarity of expression. Lists or dot points are unlikely to gain full marks.

Final answers to calculations should be expressed to the appropriate number of significant figures.

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Suggested working time: 70 minutes.

Question 28 **(11 marks)**

Iodic acid (HIO_3) is found as a white solid at room temperature. It readily dissolves in water to produce an acidic solution, with a solubility of 2.69 kg L^{-1} at 20 ˚C. Iodic acid can be used in analytical chemistry to standardise alkaline solutions.

Iodic acid also acts as a strong oxidising agent under acidic conditions. When behaving as an oxidant, it can be reduced to either elemental iodine (I_2), iodide ions (I^-) or, under the right conditions, to the iodine trichloride dimer (I_2Cl_6) which is golden yellow in solution.

A solution of acidified iodic acid has some toxic carbon monoxide gas bubbled through it. A brown solution is observed to form, as the carbon monoxide is converted to the less harmful carbon dioxide gas.

(a) Write the oxidation and reduction half-equations and the overall redox equation for this reaction. (3 marks)

Oxidation half-equation	
Reduction half-equation	
Overall redox equation	

A chemistry student is experimenting with iodic acid, to investigate some of its physical and chemical properties. She wants to determine the strength of the acid, but cannot find any information about the acidity constant (K_a) of iodic acid in her research.

(b) Write an acidity constant expression for iodic acid and explain what information a K_a value would provide regarding the acid. (2 marks)

One method used to prepare iodic acid is by reacting aqueous iodine with aqueous chlorine. This produces a mixture of iodic and hydrochloric acids, as shown in the equation below;

$$I_2(aq) + 5\ Cl_2(aq) + 6\ H_2O(l) \rightarrow 10\ HCl\ (aq) + 2\ HIO_3(aq)$$

The chemistry student decided to prepare a sample of iodic acid according to the reaction above. She mixed 750 mL of 2.15×10^{-3} mol L^{-1} aqueous iodine (I_2) with 830 mL of chlorine water (Cl_2) in a large beaker. Once the reaction had finished, a mixture of iodic and hydrochloric acids was present. She used a digital pH meter to measure the resulting pH of the solution and determined it to be 2.14.

(c) Determine and justify whether iodic acid is a strong or weak acid. Use appropriate calculations to support your answer. (You may assume that the chlorine water was in excess and that the reaction went to completion, consuming all of the iodine.) (6 marks)

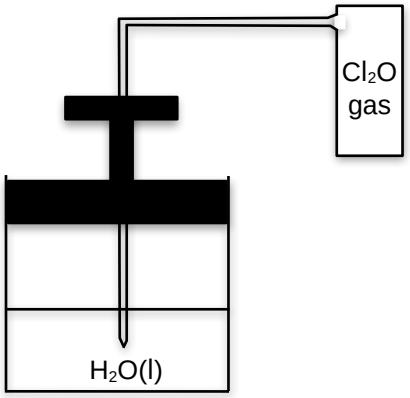
Question 29 **(12 marks)**

Dichlorine monoxide (Cl_2O) is a brownish-yellow gas at room temperature. It is very soluble in water and when dissolved, it reacts with water to produce weak hypochlorous acid, according to the reversible reaction below;

$$Cl_2O(g) + H_2O(l) + \text{heat} \rightleftharpoons 2\,HClO\,(aq)$$

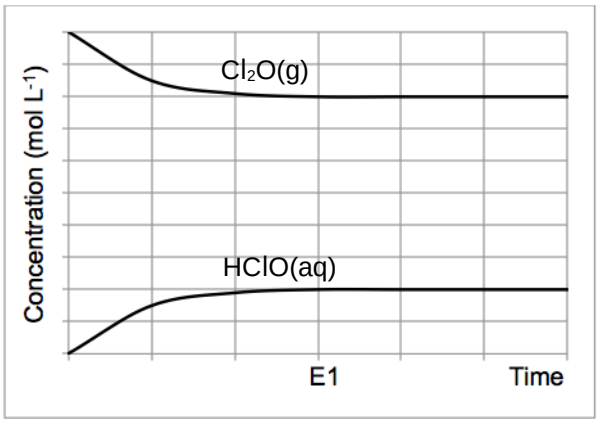
The solution of hypochlorous acid appears colourless. At room temperature (298 K) this reaction has a K_c value of 0.090.

A sample of $Cl_2O(g)$ was injected into a glass cylinder containing water, as shown in the diagram to the right, and allowed to establish equilibrium according to the equation above.

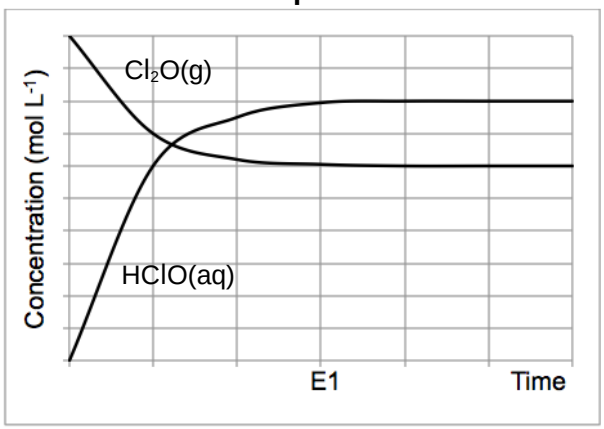


Several graphs have been sketched below, in an attempt to show the changes in concentration of $Cl_2O(g)$ and $HClO(aq)$ from Time 0, when the gas was injected into the system, until equilibrium was first established at Time E1. You may assume the scales on both axes of each graph are identical.

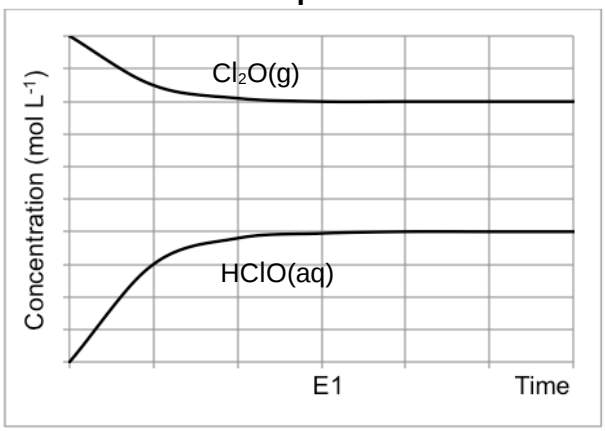
Graph A



Graph B

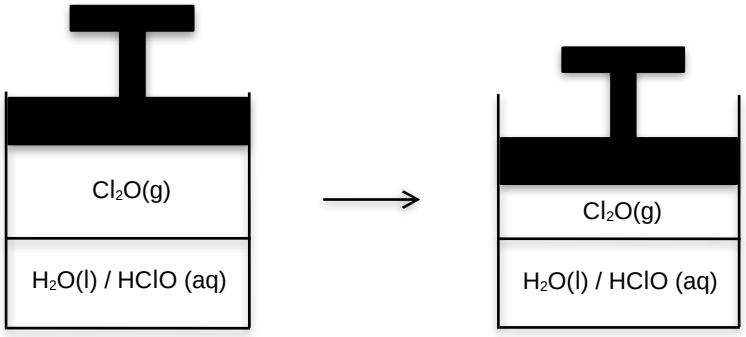


Graph C



(a) Which of these graphs (A, B or C) is **most likely** to illustrate the concentration changes that would occur, from the time the $Cl_2O(g)$ is injected into the system until the time that equilibrium is established at E1? Explain your choice below. (3 marks)

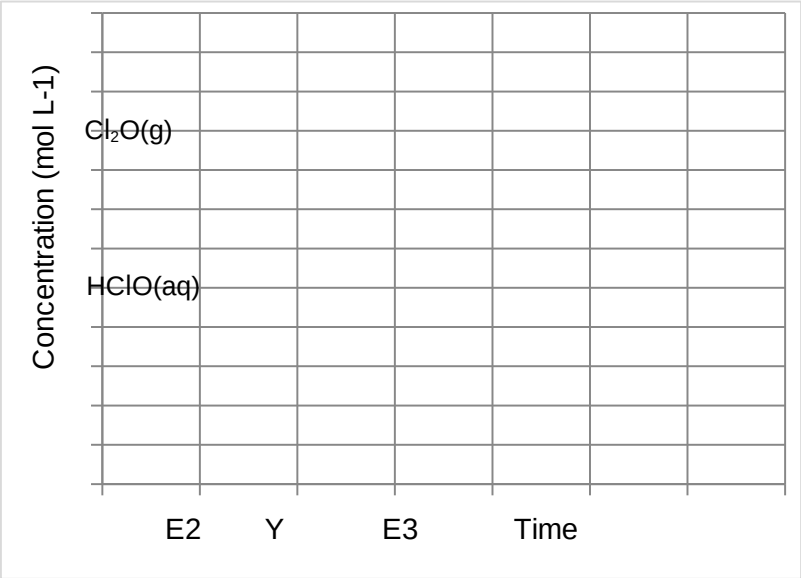
At Time X, the pressure on the system was then increased, as shown in the diagram below.



(b) State the effect this would have on the equilibrium position and describe any corresponding observations that would be made as a result of this imposed change. (3 marks)

(c) Explain what would happen to both the forward and reverse reaction rates, from the time the pressure was increased until the system re-establishes equilibrium (at E2). (3 marks)

(d) Continue the graph below, showing the effect of a temperature increase on the system (imposed at Time Y) until equilibrium is re-established at E3. (You may assume water is still in the liquid state, as a result of the previous pressure increase.) (3 marks)



Question 30 **(17 marks)**

A student was asked to determine the concentration of ammonia (NH_3) in a commercially available Cloudy Ammonia solution used for cleaning.

First, the student pipetted a 25.00 mL sample of the Cloudy Ammonia solution into a 250.0 mL volumetric flask.

50.00 mL of 1.12 mol L^{-1} $HCl_{(aq)}$ was immediately added to the volumetric flask which reacted with the ammonia in solution.

Distilled water was then added to make the solution up to 250.0 mL

20.00 mL aliquots of the resulting solution were then titrated with 0.0497 mol L^{-1} $Na_2CO_{3(aq)}$ to determine the amount of excess (unreacted) HCl in the volumetric flask.

The volumes of $Na_2CO_{3(aq)}$ required for neutralisation were recorded below.

	1	2	3
Initial reading (mL)	0.00	21.55	0.00
Final reading (mL)	21.55	43.00	21.55
Titre (mL)			

(a) Use the titration results to calculate the number of moles of excess HCl remaining in the 250.0 mL (4 marks)

(b) Use your answer from (a), as well as the **original** concentration of HCl to calculate the number of moles of NH_3 in the 25.00 mL sample. (3 marks)

(c) Calculate the percentage composition (by mass) of ammonia in the sample of Cloudy Ammonia. The mass of Cloudy Ammonia is 0.987 g per mL.
Express your answer to the correct number of significant figures. (4 marks)

The back titration is performed using a sodium carbonate primary standard as well as the indicator methyl orange.

(d) Define the term ‘standard solution’ and state two (2) characteristics of Na_2CO_3 that allow it to be used as a primary standard. (3 marks)

If the burette had been rinsed with distilled water only, at the start of the experiment;

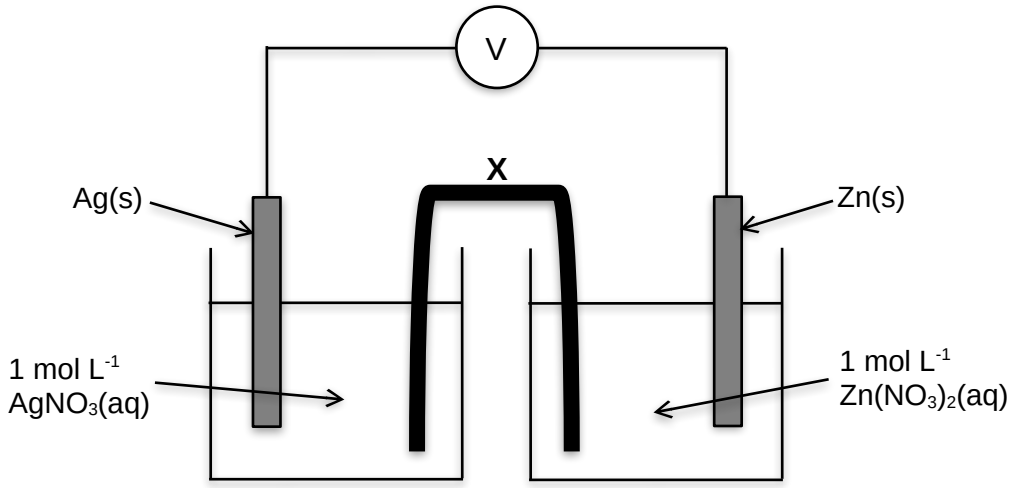
(e) What effect would this error have on the value of the titre volumes obtained (i.e. higher volumes, lower volumes or unaffected)? (1 mark)

(f) Is this a random or systematic error? Explain your answer. (2 marks)

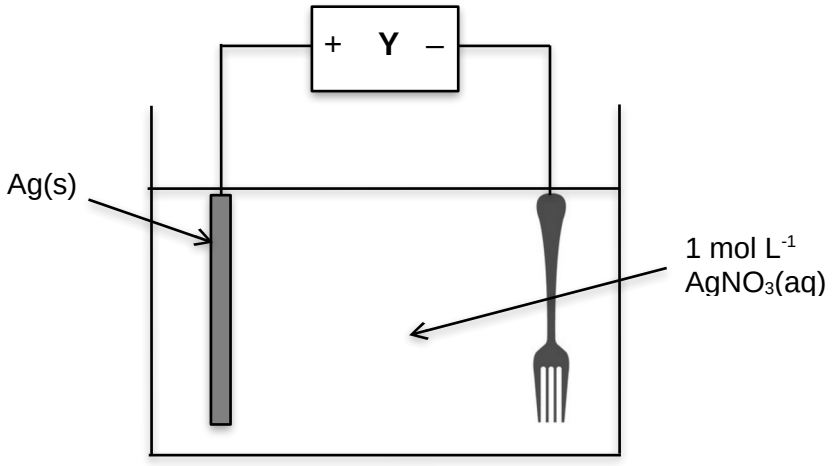
Question 31 **(16 marks)**

Consider the two cells below, both of which use a silver metal electrode as well as a silver nitrate solution.

Cell A



Cell B



(a) Complete the following table with regards to the two cells illustrated on the previous page. Your answer should;

- Classify each cell as either a galvanic or electrolytic cell.
- Give a brief description (one sentence) of the purpose of each cell.
- Complete the cathode and anode reactions for each cell. (8 marks)

	Cell A	Cell B
Type of cell		
Purpose of cell		
Cathode reaction		
Anode reaction		

Refer to the diagram of Cell A.

(b) What is X? State the role of X and explain why Cell B does not need this. (4 marks)

X is the _____.

Refer to the diagram of Cell B.

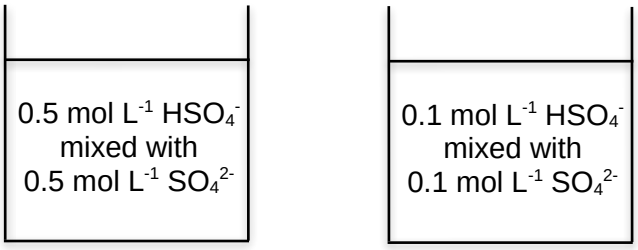
(c) What is Y? State the role of Y and explain why Cell A does not need this. (4 marks)

Y is the _____.

Question 32 **(14 marks)**

A chemistry student was investigating what type of solutions can be mixed together to form a buffer.

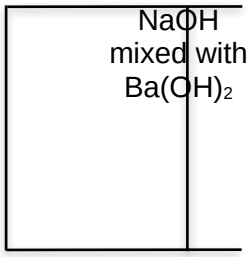
Firstly, he made two different hydrogensulfate / sulfate buffers. As illustrated in the diagrams below, one beaker contained a 1 L mixture of 0.5 mol L^{-1} $NaHSO_4(aq)$ and 0.5 mol L^{-1} $Na_2SO_4(aq)$. The second beaker contained a 1 L mixture of 0.1 mol L^{-1} $NaHSO_4(aq)$ and 0.1 mol L^{-1} $Na_2SO_4(aq)$.



Unfortunately, the student forgot to label the beakers, and could not remember which was which.

(a) Explain how the student could experimentally determine which beaker contained which buffer. Include a description of buffering capacity in your answer. Assume you have access to standard laboratory reagents and equipment. (6 marks)

Next, the student decided to mix together solutions of sodium hydroxide, NaOH, and barium hydroxide, $Ba(OH)_2$.



(b) Why doesn't this solution form a buffer? (1 mark)

_____

_____

The original sodium hydroxide solution had a pH of 9.9 and the student measured 850 mL of this into a beaker. He then added 95 mL of a 0.075 mol L^{-1} barium hydroxide solution to the same beaker.

(c) Calculate the pH of the resulting solution. (7 marks)

End of questions

Spare answer page

Question number: _____