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Mon 645-845 GEN1 online

Tues 415-615 Norm1

VCE Chemistry ¾
AOS 1 Revision II [0.11]
Workshop

Error Logbook:

New Ideas/Concepts	Didn't Read Question
Pg / Q #: Q19, Q9 Notes: only circle what we have (no Cu^{2+} or Fe^{2+}) E=VQ	Pg / Q #: _____ Notes:
Algebraic/Arithmetic/ Calculator Input Mistake	**Working Out Not Detailed Enough**
Pg / Q #: _____ Notes:	Pg / Q #: _____ Notes:

7:12

Section A: Warm Up (10 Marks)

INSTRUCTION: 10 Marks. 7 Minutes Writing.

Question 1 (1 mark)

The oxidation state of Phosphorus in the pyrophosphate ion $P_2O_7^{4-}$ is:

A. +3.5

B. +5

C. +7

D. +10

$2P+7(-2)=-4$

$2P=-4+14$

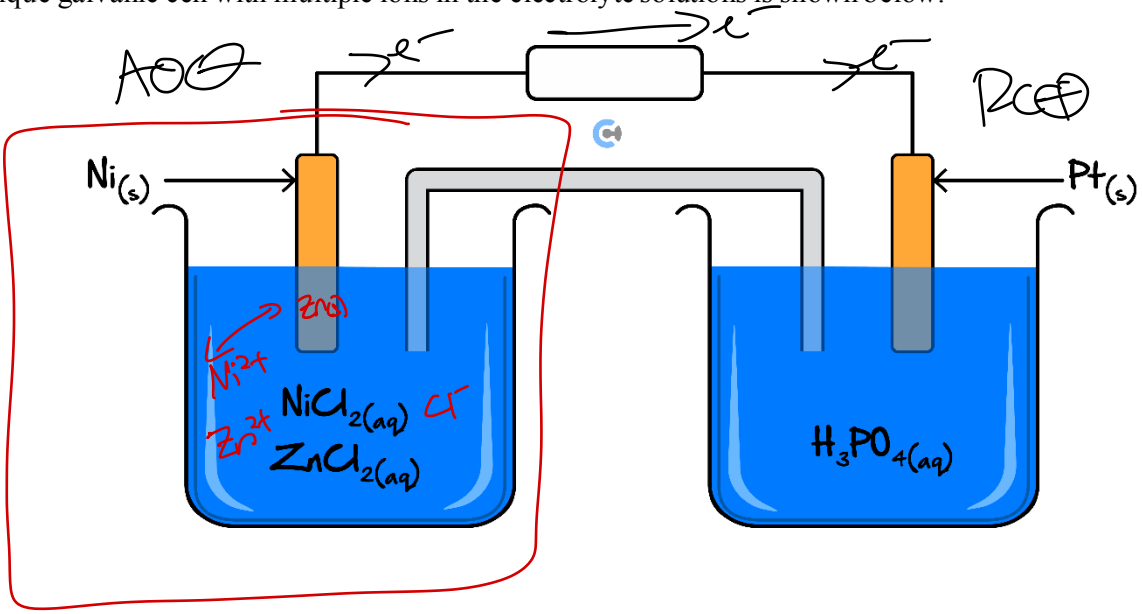
$2P=+10$

$P=+5$

Question 2 (9 marks)

A unique galvanic cell with multiple ions in the electrolyte solutions is shown below:

a.



i. State the species present which will most readily reduce. (1 mark)

$H^+_{(aq)}$

ii. Write the balanced half-equation that occurs at the cathode. (1 mark)

$2H^+_{(aq)} + 2e^- \rightarrow H_{2(g)}$

iii. Thus, state the 2 things that would be observed at the cathode as this cell operates. (2 marks)

1. bubbles (H_2 produced)
2. less acidic (H^+ used) pH increase

b. Label the direction of flow through the circuit by placing an arrow in the box provided. (1 mark)

c. Explain why the left half-cell does not use zinc as its electrode. Ensure to reference the energy transformations and any relevant half-equations. (2 marks)

If zinc were used, it would be in direct contact with $Ni^{2+}_{(aq)}$ in the electrolyte & produce thermal energy

$Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e^-$ $Ni^{2+}_{(aq)} + 2e^- \rightarrow Ni_{(s)}$

d. The cell was constructed to determine the EMF of the cell according to the electrochemical series.

i. State the theoretical EMF expected to be observed. (1 mark)

0.25 V

ii. What would the concentration of Phosphoric acid (H_3PO_4) be in the~~ir set-up?~~ ~~(1 mark)~~

$[H^+] = 1.0M$ $[H_3PO_4] = 0.33M$

$H_3PO_4 \rightleftharpoons 3H^+$

0.33M 1.0M

$H_3PO_4 \rightarrow$

H_3PO_4

$\downarrow$

$3H^+$

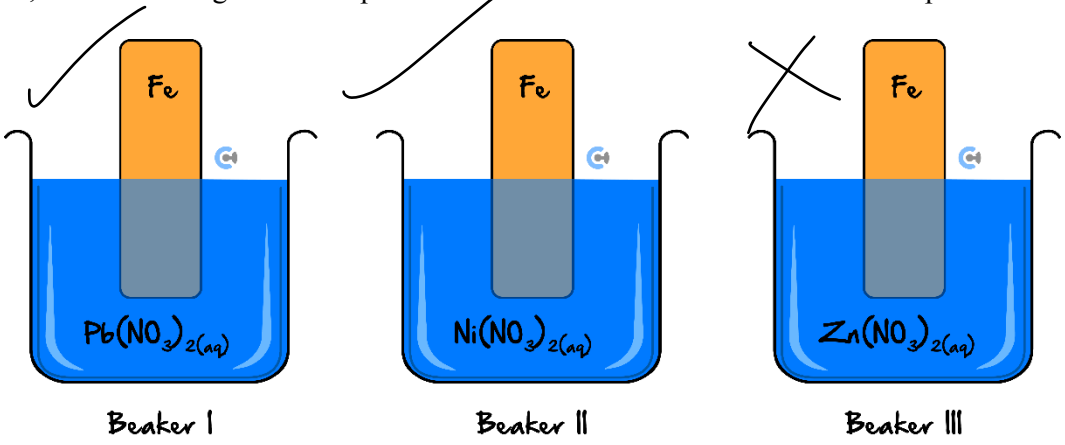
Space for Personal Notes

Section B: Ramping Up (8 Marks)

INSTRUCTION: 8 Marks. 6 Minutes Writing.

Question 3 (1 mark)

Three beakers, each containing an iron strip and a 1.0 *M* solution of a metal salt were set up as follows.



A reaction will occur in beaker(s):

A. I and II only.

B. I and III only.

C. II and IIIonly.

D. III only.

Question 4 (1 mark)

Some strips of the metals iron, zinc and silver were placed in separate beakers, each containing 1.0 *M* nickel(II) sulfate, $NiSO_4$, solution in water at 25°C.

What is expected to occur over time?

A. Ni will be deposited in all of the beakers.

B. Ni will not be deposited in any of the beakers.

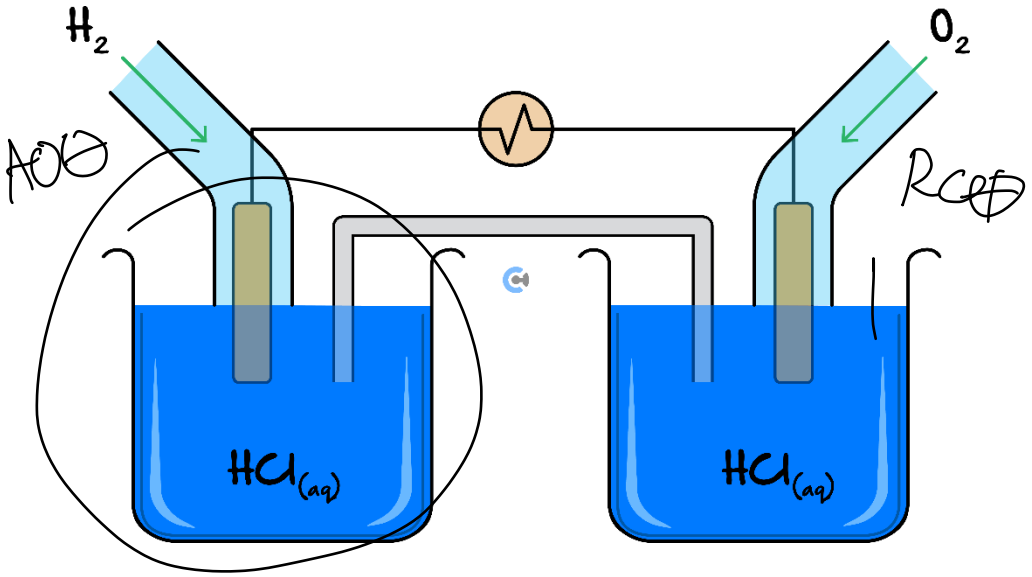
C. A reaction will occur only in the beaker containing Ag.

D. A reaction will occur only in the beakers containing Fe and Zn.

Question 5 (6 marks)

Hydrogen and oxygen gas cells are set up and compared.

a. The following hydrogen and oxygen gas cell, Cell *A* was set up in a school laboratory.



i. State a material that can be used as a material for the electrode. Justify your answer. (1 mark)

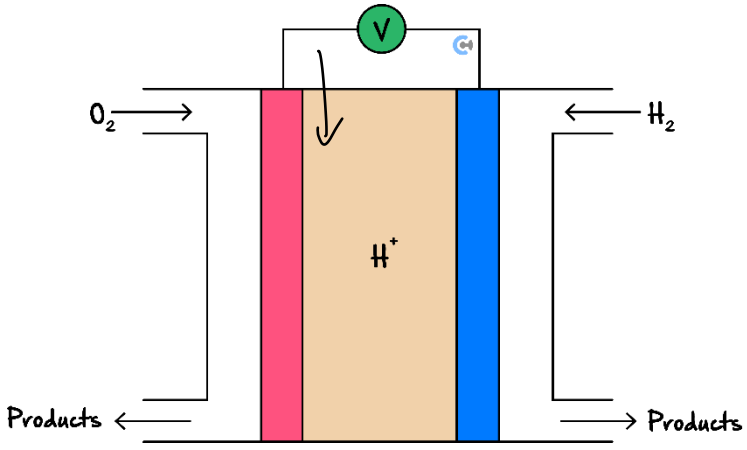
Pt(s) → inert & acts as catalyst

ii. Write the half-equation which occurs at the: (2 marks)

Anode: $H_{2(g)} \rightarrow 2H^+_{(aq)} + 2e^-$

Cathode: $O_{2(g)} + 4H^+_{(aq)} + 4e^- \rightarrow 2H_2O_{(l)}$

Suppose a pH meter was placed into the electrolyte of the following cell, Cell *B*:



b. Explain what would be observed when measuring the pH in Cell *B* compared to if pH meters were placed into each of the electrolytes of the half-cells in Cell A. (3 marks)

In cell B, the electrolyte is shared this means as H^+ is produced at anode, it is used at cathode at same rate, so pH remains constant overall. (1)

In cell A, At cathode, H^+ is used, meaning electrolyte becomes less acidic, so pH increases. (1)

At anode, H^+ is produced, becomes more acidic, pH decreases. (1)

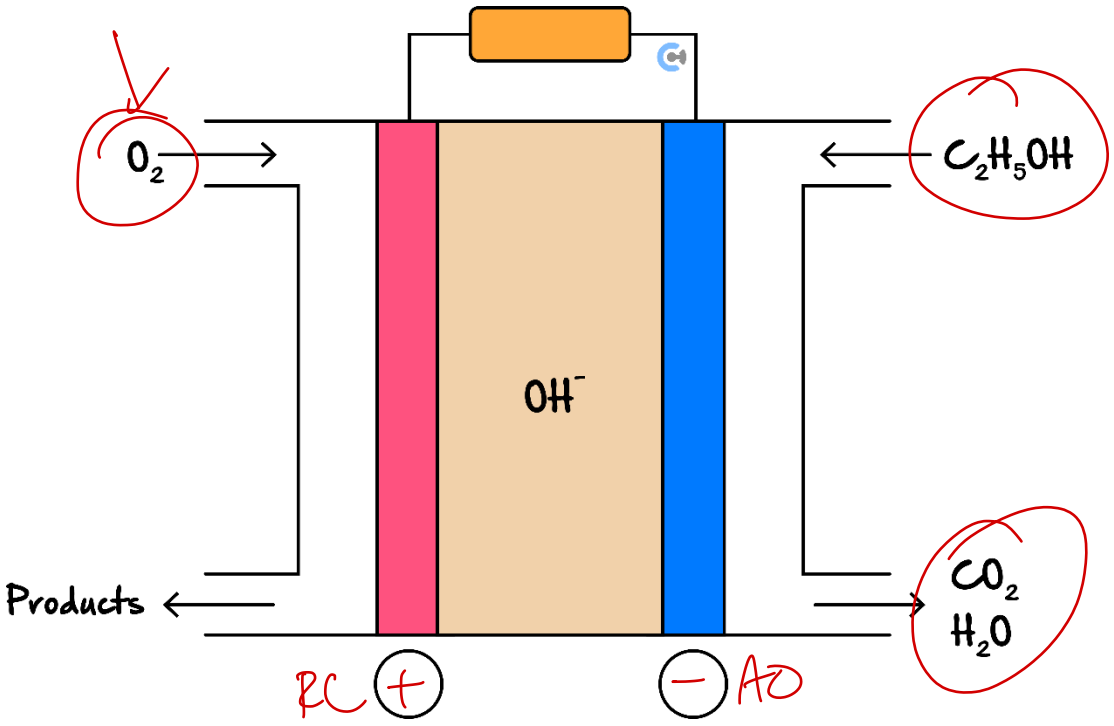
Space for Personal Notes

Section C: Getting Trickier I (11 Marks)

INSTRUCTION: 11 Marks. 9 Minutes Writing.

Question 6 (11 marks)

The following cell was prototyped at standard conditions by NASA for its potential widespread use in society in the near future.



a. State if the cell above is classified as a galvanic cell or not. Justify your answer. (1 mark)

Yes. It converts from chemical to electrical energy spontaneously & is indirect contact

b. Label the polarity of the electrodes by placing a + and – in the circles provided. (1 mark)

c. Write the balanced equation and overall reaction that takes place. (1 mark)

$C_2H_5OH_{(l)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(l)}$

d. Write the balanced half-equation for the:

i. Oxidation half-cell. (1 mark)

KOH(aq)

$C_2H_5OH + 3H_2O \rightarrow 2CO_2 + 12H^+ + 12e^-$

$+12OH^-$ $+12OH^-$

$C_2H_5OH + 12OH^- \rightarrow 2CO_2 + 9H_2O + 12e^-$

(l) (aq) (g) (l)

ii. Reduction half-cell. (1 mark)

$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

(g) (l) (aq)

e. It is found that this cell generates 1.174 *V* at SLC.

i. Find the standard electrode potential of the oxidation half-equation. (1 mark)

$E^\ominus = 0.40V - 1.174V = -0.774V$

$= -0.77V$

ii. Calculate the volume of oxygen needed for this cell to be able to generate 3.00 *MJ* of energy. (3 marks)

$\Delta H = \frac{q}{n}$ $n(C_2H_5OH) = \frac{q}{\Delta H} = \frac{3000kJ}{1370kJ/mol} = 2.19mol$

$n(O_2) = 3n(C_2H_5OH) = 3 \times 2.19mol = 6.57mol$

$V(O_2) = nV_m = 6.57 \times 24.8 = 163L$

f. These cells are yet to be widely implemented in society.

State **two** features of these cells that make them difficult to use in day-to-day devices such as ~~motor vehicles~~ phones. Explain your answer with reference to at least **one** United Nations Sustainable Development Goals. Use item **26.i.** of the Data Book. (2 marks)

(1) ~~Fuel cells are expensive, as electrode must be porous which is expensive, materials which are catalytic, inert~~ and conduct electricity are expensive (e.g. Pt & Au) - this relates to United Nations Sustainable Development Goal 7 :Affordable and clean energy" where fuel cells are clean but not affordable.

(1) Continuous supply is not suitable for use in things like phones because it's unsuitable for portable applications .

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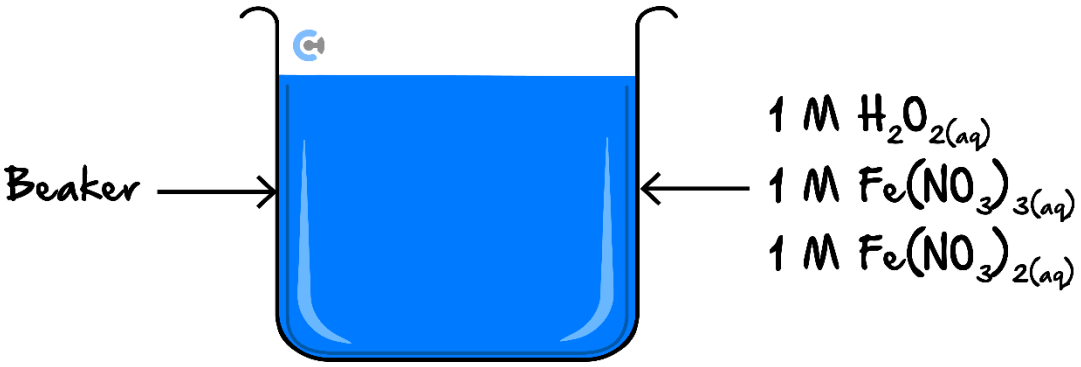
Section D: Getting Trickier II (11 Marks)

INSTRUCTION: 11 Marks. 10 Minutes Writing.

Question 7 (1 mark)

At standard conditions, solutions of Hydrogen peroxide, H_2O_2 , iron(III) nitrate, $Fe(NO_3)_3$ and iron(II) nitrate, $Fe(NO_3)_2$, were added to a beaker. The initial concentrations of H_2O_2, $Fe(NO_3)_3$ and $Fe(NO_3)_2$ in the beaker were all 1 M.



Which one of the following statements is correct?

A. Iron, Fe, is deposited at the bottom of the beaker.

B. The two half-reactions in the beaker immediately produce 1.09 V.

C. The concentration of $H_2O_2(aq)$ decreases immediately since it is the strongest reducing agent.

D. The temperature of the contents in the beaker decreases immediately when $Fe(NO_3)_3(aq)$ reacts with $H_2O_2(aq)$.

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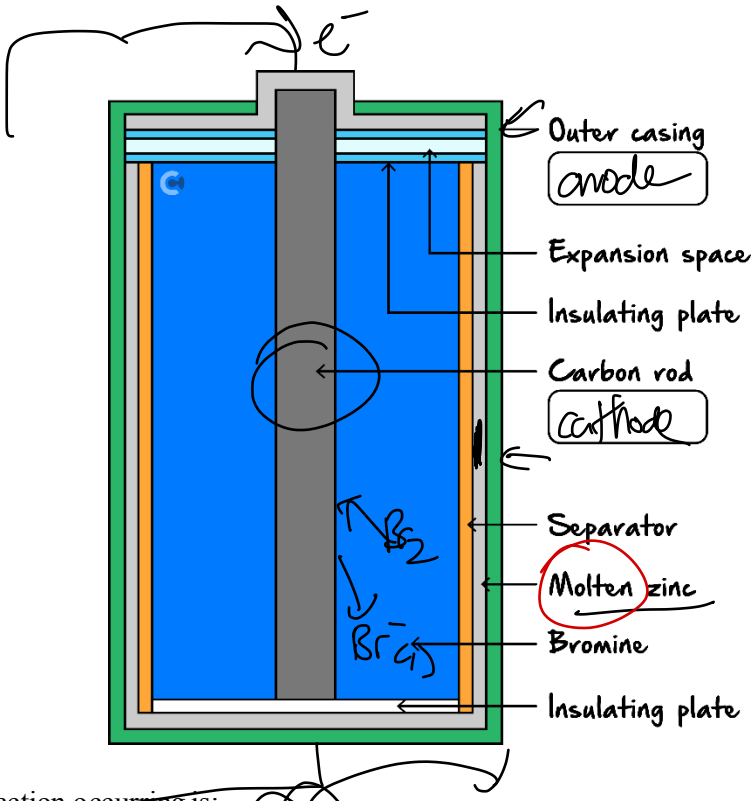
Question 8 (10 marks)

The following primary cell is being studied by chemists to determine whether it is viable for day-to-day use in society.



Given the overall ~~reaction occurring~~ is:

$$Zn(l) + Br_2(l) \rightarrow ZnBr_2(l)$$

0 → +2

0 → −1

a.

i. Explain, using oxidation numbers, which species is the reducing agent. (1 mark)

reducing agent itself undergoes oxidation.

Zn(s) is oxidising as O.N changes from 0 → +2.

ii. Identify which physical component is acting as the anode in the cell - the outer casing or the carbon rod - by labelling one of the boxes on the diagram above. (1 mark)

iii. Label the cathode above and explain the chemistry occurring in the region surrounding the cathode. (2 marks)

Near cathode, $Br_{2(l)}$ will migrate towards inert carbon electrode, receive e⁻ through external circuit & turn into Br^-

b. Explain the purpose of the separator. (1 mark)

To ensure reactants do not come in direct contact to one another.

c. The insulating plates within the cell ensure humans do not get burned when handling the cell. List and explain **two** reasons why the cell gets very hot when operating. (2 marks)

1. Cell is in molten conditions which means it already operates at high temperatures (1)
2. Reaction is exothermic, releases some heat which makes cell even hotter. (1)

t I E

d. The cell is left running for an hour and produces a stable current of 5.0 A and a total of 300 kJ of electrical energy.

EMF ↔ V

i. Calculate the electromotive force produced by the cell. (2 marks)

$E = VIt$

$V = \frac{E}{It} = \frac{300 \times 10^3 J}{5A \times 60 \times 60} = 16.7 V$

$E = VIt = J$

ii. If the main goal was to produce the maximal possible EMF, propose an alternative molten metal to use in this cell instead of zinc. (1 mark)

Li(s)

Let's take a BREAK!

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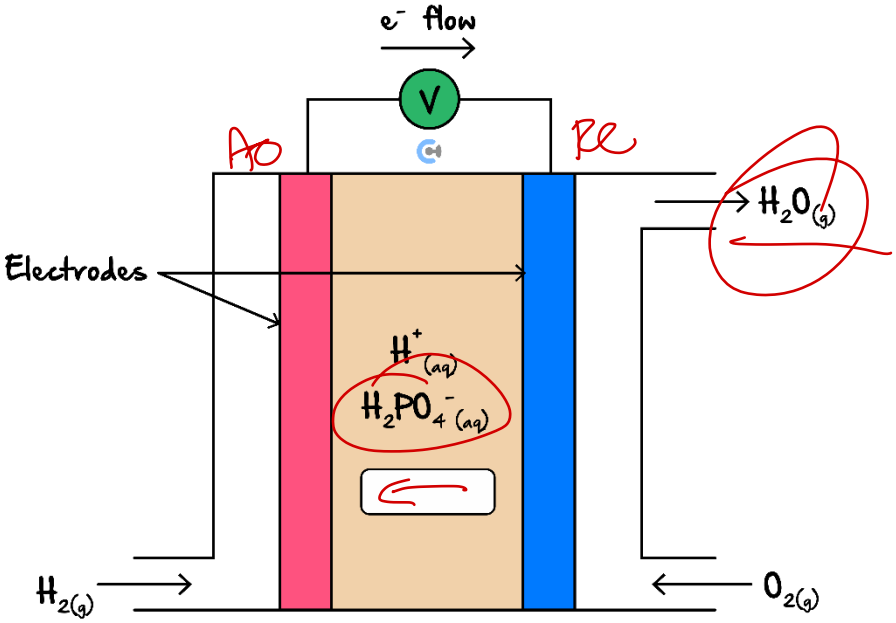
Section E: VCAA-Level Questions I (8 Marks)

INSTRUCTION: 8 Marks. 0.5 Minutes Reading. 7 Minutes Writing.

Question 9 (8 marks) (7:08) 18

A fuel cell that can provide power for buses is the phosphoric acid fuel cell, PAFC. The electrolyte is concentrated phosphoric acid and the reactants are hydrogen and oxygen gases.

A simplified sketch of a phosphoric acid fuel cell is given below.



a. Give the equation for the half-reaction that takes place at the:

i. Anode of this cell. (1 mark)

$H_2 \rightarrow 2H^+ + 2e^-$ (g) (aq)

ii. Cathode of this cell. (1 mark)

$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$ (g) (aq) (g)

b. **On the diagram** of the fuel cell, draw an arrow to show the direction in which the $H_2PO_4^-$ ion moves as the cell delivers an electrical current. (1 mark)

E = VH → Q = It

c.

V

E = VQ

↓

i. A particular cell operates at 0.92 *V*. How much energy, in *kJ*, is delivered per mole of hydrogen in this fuel cell? (2 marks)

$n(H_2) = 1\,mol$, $n(e^-) = 2n(H_2) = 2\,mol$

$Q = n(e^-)F = 2 \times 96500 = 193000\,C$

$E = VQ = 0.92V \times 193000\,C = 177560\,J$

$= 1.8 \times 10^2\,kJ$

ii. By comparing the energy delivered per mole of hydrogen in the fuel cell and the heat of combustion of hydrogen, calculate the energy efficiency of this fuel cell. (1 mark)

$\%\,eff = \frac{\Delta H(ele)}{\Delta H(theo)} \times 100\% = \frac{178}{286} \times 100\% = 62.2\%$

$= 62\%$

$H_2O_{(l)}$

d. Describe one advantage and one disadvantage of such a fuel cell compared with a petrol-driven car engine. (2 marks)

Advantage:

more energy efficient as it has a direct energy conversion chemical to electrical, compared to multiple conversions in petrol cars which have more energy loss.

Disadvantage:

Fuel cells are expensive due to electrodes being made of metals which are inert, catalytic & conduct electricity (e.g. $Pt_{(s)}$ or $Au_{(s)}$) $H_{2(g)}$ is difficult to store & is highly flammable.

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Section F: Multiple Choice Questions (9 Marks)

INSTRUCTION: 9 Marks. 9 Minutes Writing.

Question 10 (1 mark)

Inspired from VCAA Chemistry Exam 2002
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/chem22002.pdf#page=4

A VCE chemistry student sets up a galvanic cell using two standard half-cells with half-reactions:

Half-cell 1: $Cr^{3+}(aq) + e^- \rightarrow Cr^{2+}(aq)$

Half-cell 2: $Cr(s) \rightarrow + Cr^{2+}(aq) + 2e^-$

Suitable materials for the electrodes of the two half-cells are:

	Half-cell 1	Half-cell 2
A.	Platinum	Platinum
B.	Platinum	Chromium
C.	Chromium	Chromium
D.	Chromium	Platinum

Question 11 (1 mark)

Which statement about the electrochemical series is correct?

A. Strong oxidising agents have strong conjugate-reducing agents.

B. The stronger the reductant, the more positive the E^0 value.

C. The stronger the reductant, the closer to zero the E^0 value.

D. Strong reducing agents donate electrons more readily than weak ones.

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Question 12 (1 mark)

Perchloric acid, $HClO_4$, is an extremely strong acid and a very powerful oxidising agent.

Which of the following formulae represents the substance **least likely** to be produced when perchloric acid acts as the oxidant in a redox reaction?

A. Cl_2

B. Cl_2O

C. Cl_2O_2

D. Cl_2O_7

Question 13 (1 mark)

The iron(II) ion, $Fe^{2+}(aq)$:

A. Can act as an oxidant but not a reductant.

B. Can oxidise solid zinc and reduce liquid bromine.

C. Can act as a reductant but not an oxidant.

D. Will always be reduced to $Fe(s)$ in redox reactions.

Question 14 (1 mark)

A series of galvanic cells were constructed using four metals (A, B, C, D) and four 1 M solutions $(A^{2+}, B^{2+}, C^{2+}, D^{2+})$, it was found that:

- When the half-cell A/A^{2+} was connected to a B/B^{2+} half-cell, electrons flowed from metal A to metal B.
- When metal C was added to a solution of D^{2+}, a coating of metal D appeared on metal C.
- When the half-cell A/A^{2+} was connected to a D/D^{2+} half-cell, the mass of metal D decreased.

The ranking of metals from weakest reductant to strongest reductant would be:

A. B, A, D, C

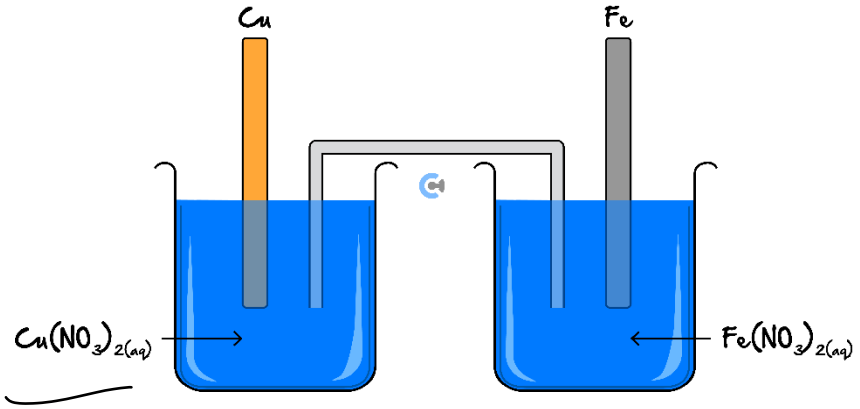
B. A, B, C, D

C. C, D, A, B

D. B, D, A, C

Question 15 (1 mark)

A student sets up a galvanic cell using two standard half-cells as illustrated below:



The solutions are connected to each other with a salt bridge consisting of an inverted U-tube containing an appropriate electrolyte.

Which species below could be used as the electrolyte for the salt bridge in the illustrated cell?

A. CH_3OH

B. $NH_4(NO_3)$

C. $AgNO_3$

D. KOH

Question 16 (1 mark)

A galvanic cell can be constructed by combining a standard hydrogen half-cell to a standard Ni^{2+}/Ni half-cell. In this galvanic cell:

A. The concentration of nickel(II) ions would decrease.

B. Reduction would occur at the nickel electrode.

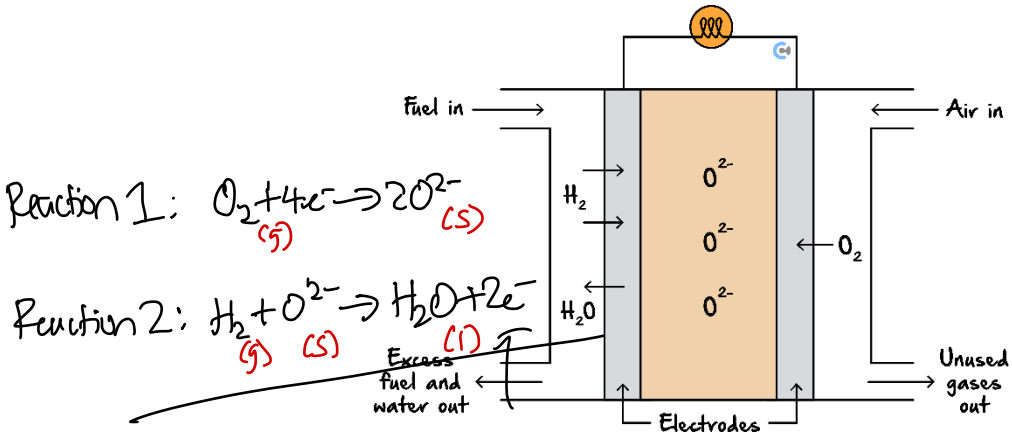
C. The pH of the solution in the standard hydrogen half-cell would increase.

D. Hydrogen gas would be consumed at the anode.

Space for Personal Notes

The following information applies to the two questions that follow

Solid oxide fuel cells (SOFC) are being considered for power generation and for use in space because of their high efficiency, high power density and extremely low pollution. A simplified diagram showing the key parts of a SOFC is shown below.



Question 17 (1 mark)

When the SOFC is generating electricity, which of the following statements is most likely to be correct?

I. Chemical energy is completely converted into electrical energy.

II. The reduction of the oxidant consumes electrons.

III. The fuel undergoes oxidation and its oxidation number Increases.

A. I only.

B. II and III only.

C. I and II only.

D. III only.

Question 18 (1 mark)

In this cell:

A. Reaction 2 occurs at the anode which is negative.

B. Reaction 2 occurs at the anode which is positive.

C. Reaction 2 occurs at the cathode which is negative.

D. Reaction 2 occurs at the cathode which is positive.

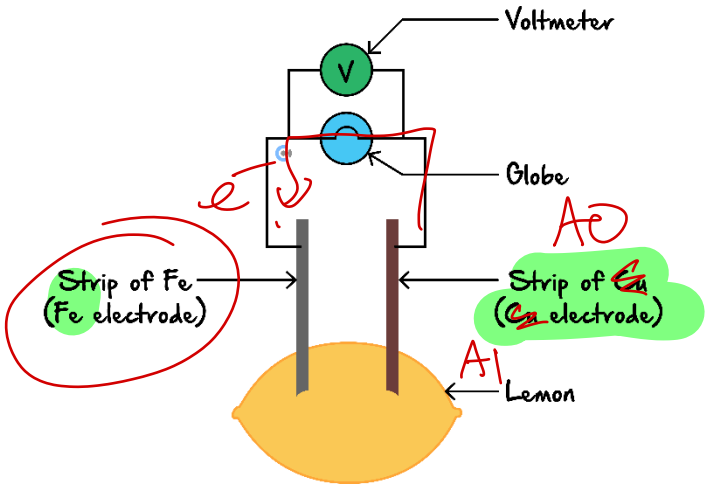
Section G: VCAA-Level Questions II (8 Marks)

INSTRUCTION: 8 Marks. 0.5 Minutes Reading. 7 Minutes Writing.

Question 19 (8 marks) 2017 NHT

Some students set up a 'lemon battery' experiment using freshly sanded strips of copper, Cu, and iron, Fe, as the electrodes.

The students closed the switch, measured the voltage and determined the direction of the flow of electrons in the external circuit. A diagram depicting their experiment and a table of their results are shown below.



Results:

Voltage	0.35 V
Movement of electrons.	From Fe to Cu.

a. Lemon juice can be considered as an aqueous solution of H^+ ions.

Write balanced half-equations for the reactions at the electrodes in the copper-iron lemon battery. (2 marks)

- Cu electrode: $2H^+_{(aq)} + 2e^- \rightarrow H_{2(g)}$
- Fe electrode: $Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + 2e^-$

b. Identify the electrode that acts as the cathode. (1 mark)

Cu electrode

c.

i. Using the electrochemical series, find the theoretical voltage for this lemon battery. (1 mark)

+0.44 V

ii. Explain why the experimental value of the voltage is different from the theoretical voltage. (2 marks)

Setup is not at standard conditions, as temp might not be 25°C, c(H+) might not be 1.0M.

d. The Cu electrode in the lemon battery is replaced with a freshly sanded strip of aluminium, Al.

For this aluminium-iron lemon battery, state the expected direction of electron flow. Justify your answer. (2 marks)

Al → Fe electron flow –

Al becomes new strongest reductant, oxidises in preference to Fe according to $Al_{(s)} \rightarrow Al^{3+}_{(aq)} + 3e^-$;

∴ Al acts as anode now

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