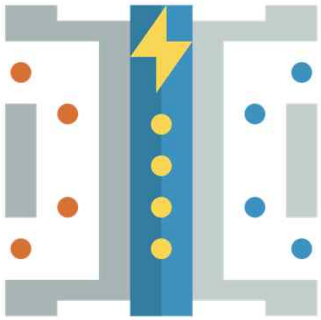


Electrochemistry

Wed 10:00am – 12:30pm

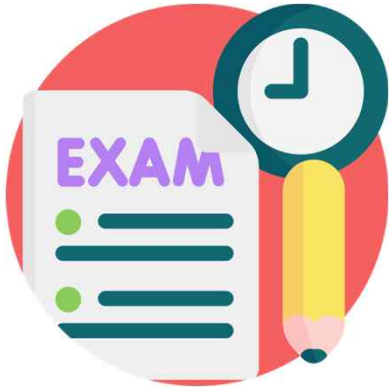
Dr.-Ing. Youjin Kim
youjinkim@jbnu.ac.kr

04.19. Wed. Lecture 7

- Attendance Check
- Student Activity (04.12.) Review
- Student Activity 04.19. Notice
- Mid-Term Notice

Mid-Term Notice (OFFLINE)

- **04/26 Wed 10:00am – 11:am, Lecture Room 505**
- **No Smart Phone (Please submit it)**
- **Contents**
  - Lecture 1 – 6
  - Student Activities (80%)
  - More than Student Activities (20%)



MAY 2023

SUN	MON	TUE	WED	THU	FRI	SAT
30	1	2	3 **Offline**	4	5	6
7	8	9	10 **Online**	11	12	13
14	15	16	17 **Offline**	18	19	20
21	22	23	24 **Offline**	25	26	27
28	29	30	31 **Online**	1	2	3

04.12. Electrochemistry Student Activity

Name (Student Number):

Q1. When **the electrochemical cell** consists of Sn and Ag with the below standard reduction potential,

$$Ag^{+}(aq) + e^{-} \rightarrow Ag\ (s) \quad E^{0}_{Ag} = +0.80V$$

$$Sn^{2+}(aq) + e^{-} \rightarrow Sn\ (s) \quad E^{0}_{Sn} = -0.14V$$

(1) The cathode is (Ag / Sn) and it is (oxidized / reduced).
(2) The anode is (Ag / Sn) and it is (oxidized / reduced).
(3) High standard reduction potential means (high / low) ionization tendency.
(4) Sn has (higher / lower) standard reduction potential than hydrogen.

Standard Reduction Potentials (in V)

- Any electrode at which a reduction half-reaction shows a greater tendency to occur than hydrogen reduction

☞ **Positive potential value**

= Less ionization tendency = Higher electroneutrality

- Any electrode at which a reduction half-reaction shows a lesser tendency to occur than hydrogen reduction

☞ **Negative potential value**

= Higher ionization tendency = Lower electroneutrality

$Ag^+ + e^- \rightarrow Ag$	+0.80
$2H^+ + 2e^- \rightarrow H_2$	0.00
$Li+ + e^- \rightarrow Li$	−3.04

Q2. Enthalpy & Entropy Concept

(1) The measure of heat flow is (Enthalpy / Entropy).

(2) The measure of heat distribution is (Enthalpy / Entropy).

(3) When the pressure is constant in the system, write the equation of Enthalpy: $\Delta H = q$

Enthalpy (H)

Enthalpy change in the system:

$$\Delta H = \Delta E + P\Delta V$$

$$\Delta H = q - w + \Delta(PV)$$

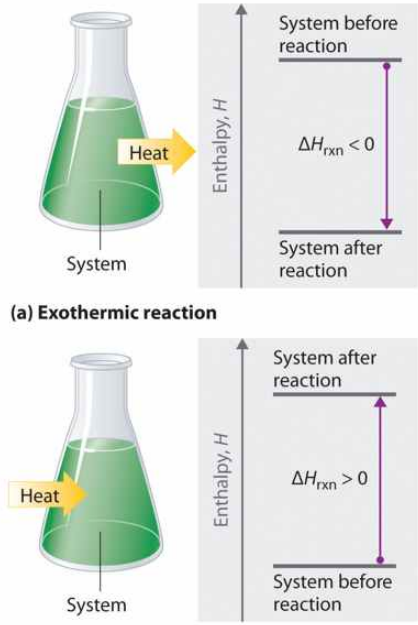
Constant Pressure,

$$\Delta H = q - w + P\Delta V$$

$$\Delta H = q - P\Delta V + P\Delta V$$

Enthalpy change is the same as heat.

$$\Delta H = q$$



Enthalpy (lardbucket.org)

Q3. Gibbs Free Energy

(1) Gibbs Free Energy explains the (**Spontaneity**) of a chemical or electrochemical process.

(2) Please write the Gibbs Free Energy equation:

$$\Delta G = \Delta H - T\Delta S$$

(3) When the process is spontaneous, ΔH is (positive / negative).
ΔS is (positive / negative).

(4) Fill in the ( ) with + or – sign in the table.

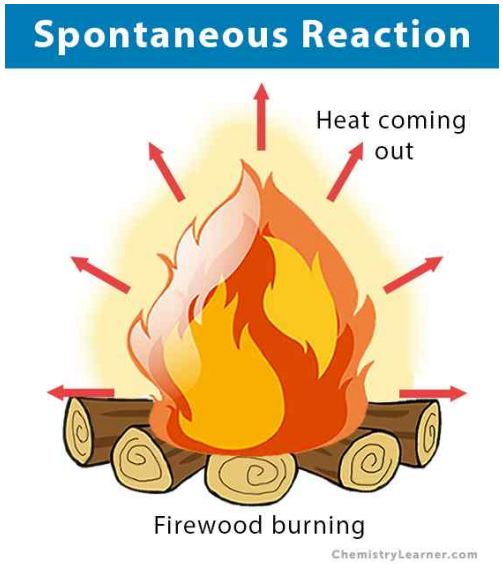
ΔG	=	ΔH	-	$T\Delta S$	
(+)		(+)		(-)	Energetically unfavorable Entropically unfavorable Never spontaneous

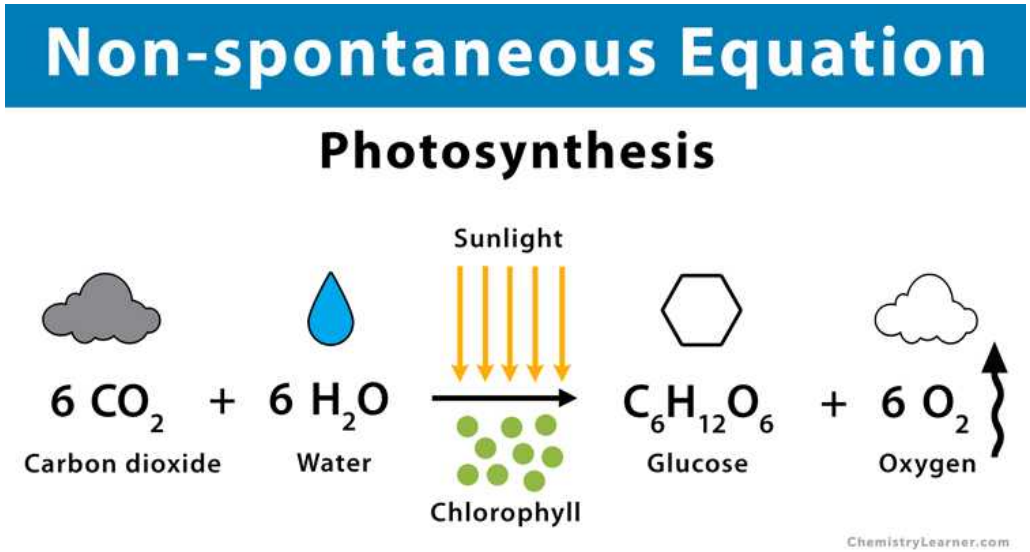
(5) Write one example of spontaneous reaction.

Respiration

Gibbs Free Energy

- Free energy provides a criterion for predicting the direction of chemical or electrochemical reactions and the composition of the system at equilibrium.
- It tells us about the “Spontaneity” of a process.





Spontaneous and Non-spontaneous Reaction: Definition and Examples (chemistrylearner.com)

Gibbs Free Energy

$$\Delta G = \Delta H - T\Delta S$$

ΔG < 0 Spontaneous

ΔG > 0 Non-spontaneous

Enthalpy & Entropy

- Enthalpy (H) is a measure of heat flow in a chemical reaction.
- Entropy (S) is a measure of disorder / heat distribution.

$$\Delta G = \Delta H - T\Delta S$$

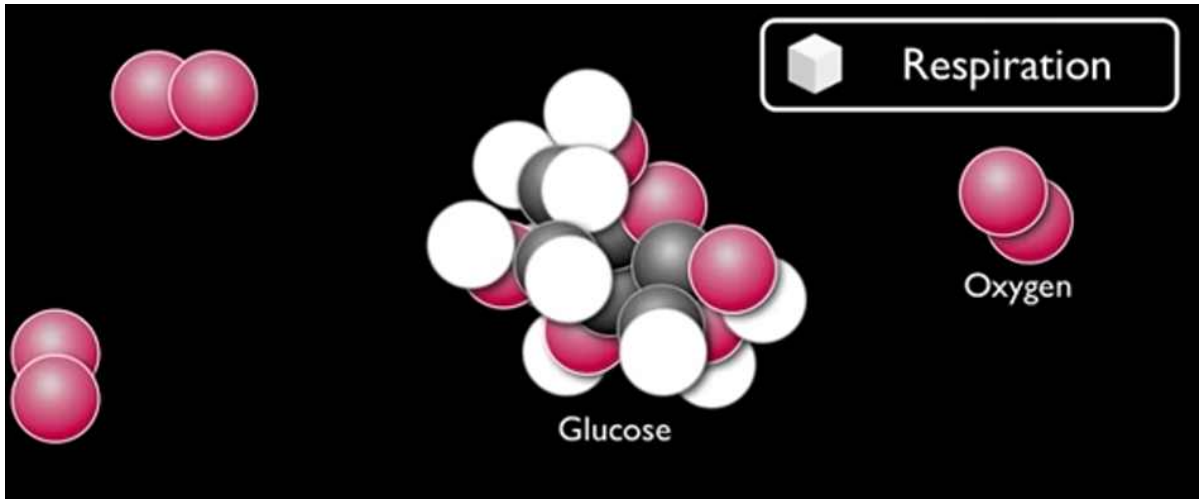
$\Delta H < 0$ Energetically favored

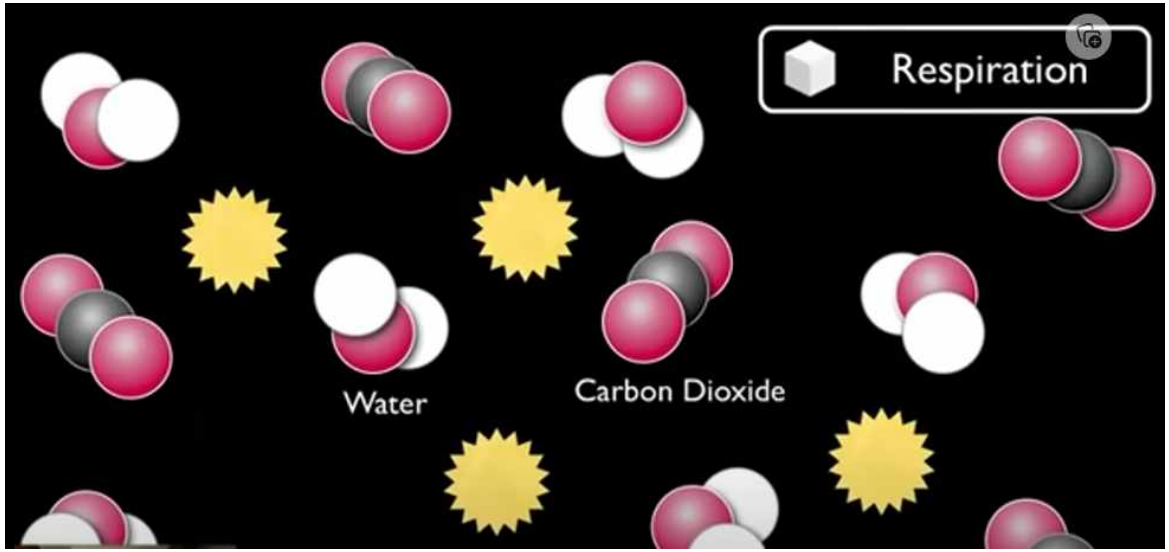
$\Delta S > 0$ Entropically favored

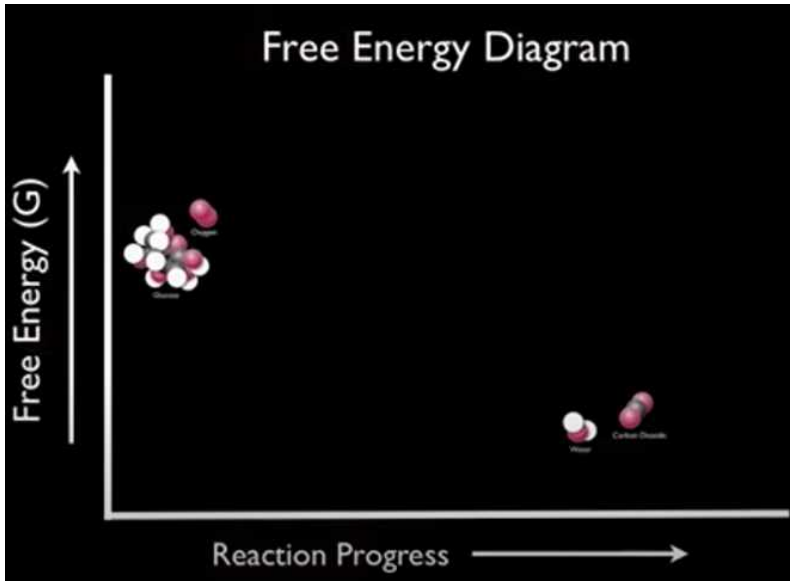
Gibbs Free Energy

$$\Delta G = \Delta H - T\Delta S$$

ΔG	$=$	ΔH	$-$	$T\Delta S$	
-		-		+	Energetically favorable Entropically favorable Always spontaneous
+		+		-	Energetically unfavorable Entropically unfavorable Never spontaneous
+/-		+		+	Energetically unfavorable Entropically favorable Spontaneous at high T
+/-		-		-	Energetically favorable Entropically unfavorable Spontaneous at low T

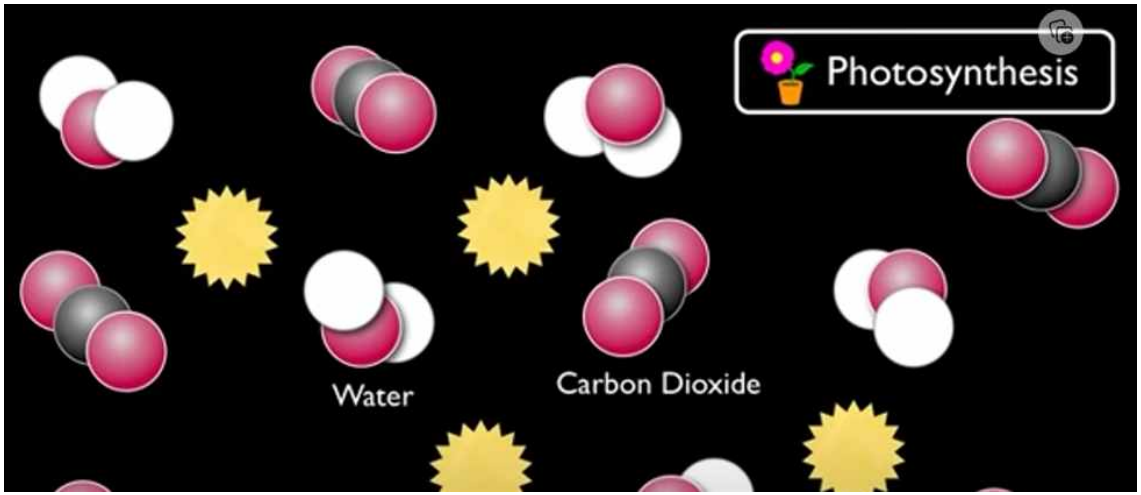


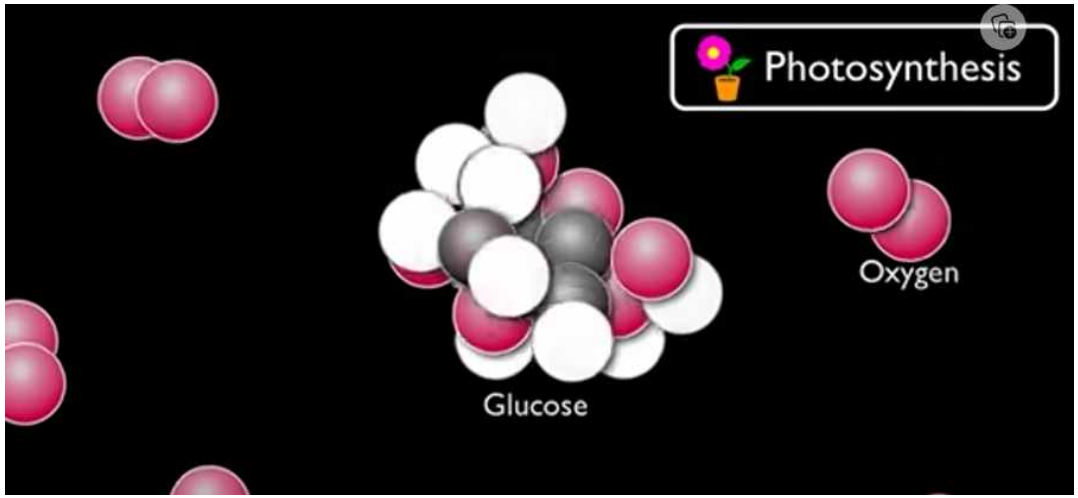


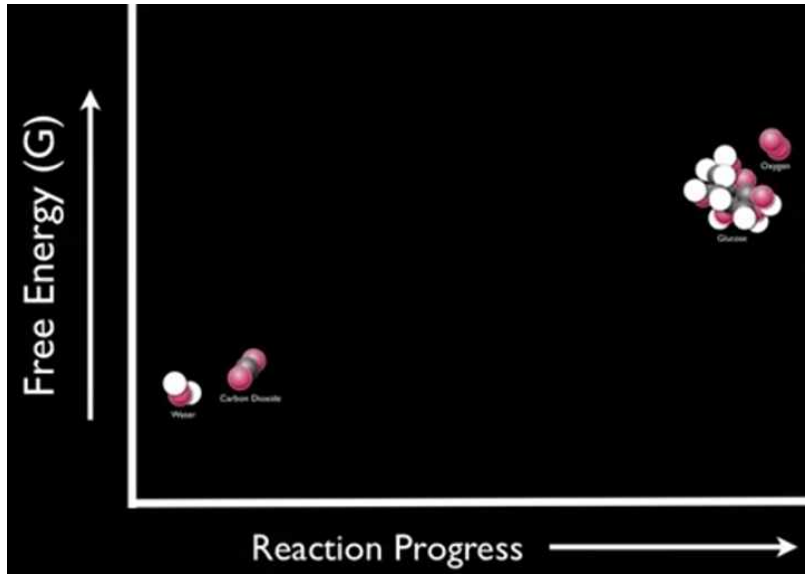


ΔG=-636kJ/mol

[Gibbs Free Energy | Bozeman Science – YouTube](https://www.youtube.com/watch?v=DPjMPeU5OeM)
https://www.youtube.com/watch?v=DPjMPeU5OeM







$\Delta G = +636 kJ/mol$

[Gibbs Free Energy | Bozeman Science – YouTube](https://www.youtube.com/watch?v=DPjMPeU5OeM)
https://www.youtube.com/watch?v=DPjMPeU5OeM

Q4. When the reaction below is given,

(1) Calculate the free Gibbs energy, ΔG.

$$CH_3CH_2OH + O_2 \rightarrow CH_3COOH + H_2O$$

$$\Delta H = -490\ kJ$$

$$\Delta S = -120\ J/K$$

$$T = 298K$$

$$\Delta G = \Delta H - T\Delta S$$

= - 490kJ – 298K*(-120J/K)

= - 490*10^3 +35,760

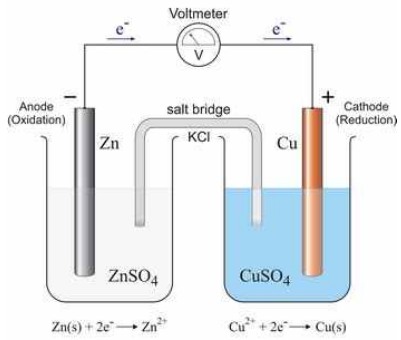
= - 454,240J

(2) It is (spontaneous / non-spontaneous) reaction.

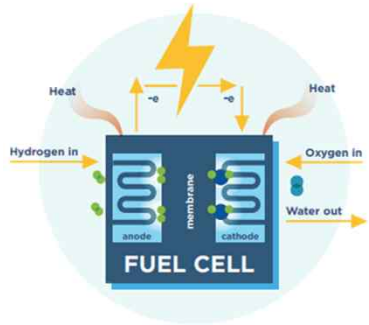
Q5. What is the difference between batt ery and fuel cell?

Charging & Discharging Process itself is limited!

- The difference between batteries and fuel cells is that batteries can deliver **a limited and predetermined amount of electricity** based on **the finite quantity of reactants** in their enclosed casing,
- While fuel cells operate as long as reactants (fuel and oxidant) are supplied from external sources.



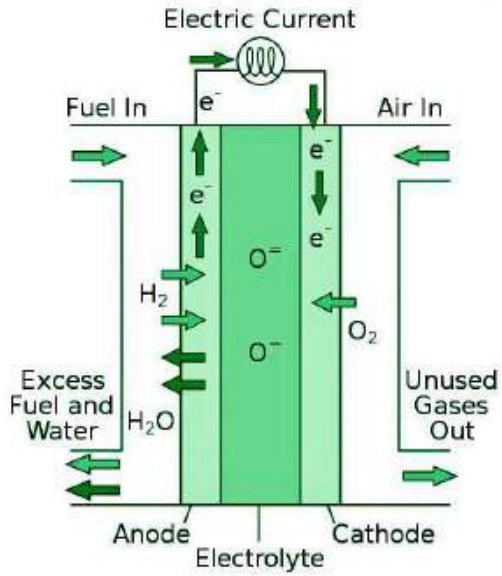
https://glossary.periodni.com/glossary.php?en=galvanic+cell

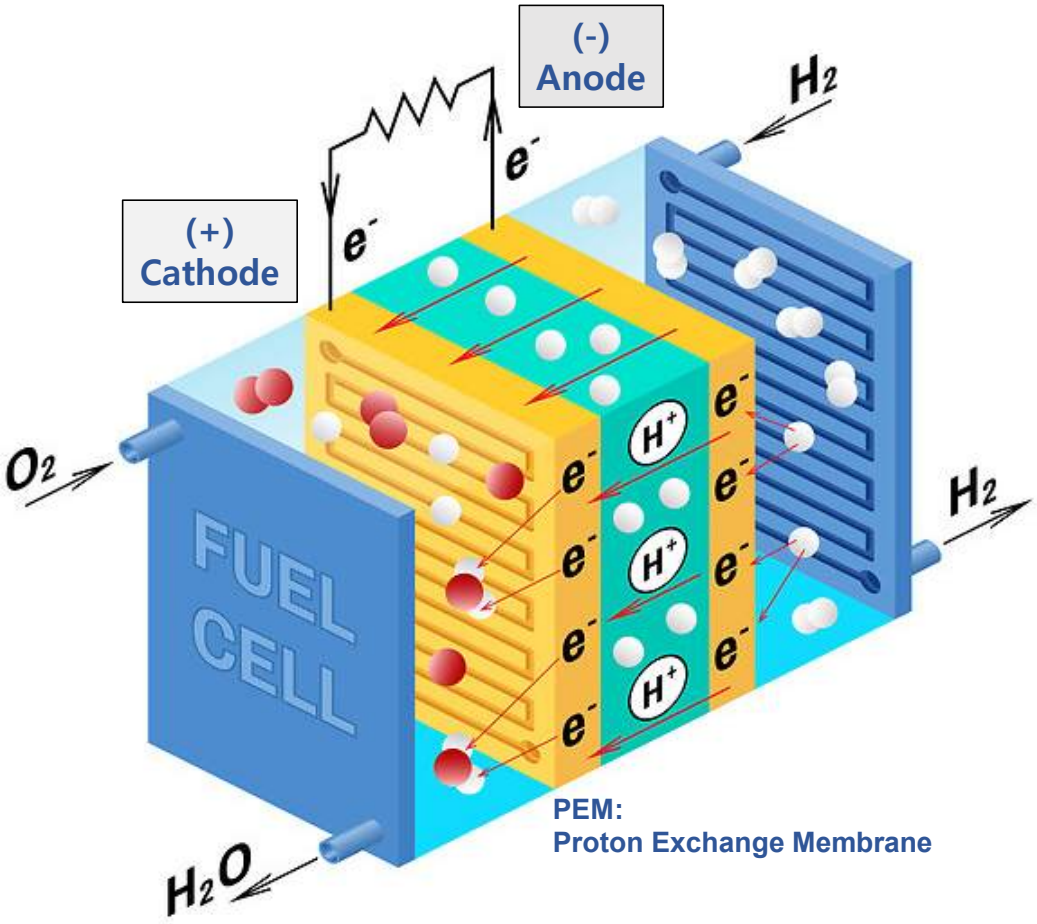


Fuel Cell Basics — Fuel Cell & Hydrogen Energy Association (fchea.org)

Q6. The batt ery can generates the electricity as long as the fuel is provided to the cell:
(O , X).

Q7. In the hydrogen fuel cell, hydrogen is put into (cathode / anode).
The hydrogen proton moves to (cathode / anode) through PEM,
while the electrons go through (external / internal) circuit to generate electricity.





Hydrogen fuel cells, explained | Airbus

- **Hydrogen** enters the fuel cell via the **anode**.
  - Hydrogen atoms react with a catalyst and split into electrons and protons.
  - **Oxygen** from the ambient air enters on the other side through the **cathode**.
- The positively charged protons pass through **the porous electrolyte membrane (PEM)** to the cathode.
- The negatively charged **electrons flow out of the cell**
  - Generate an **electric current**
  - To power an electric or hybrid-electric propulsion system.
- In the **cathode**,
  the protons and oxygen then combine **to produce water**.

Q8. In the hydrogen car, the (hydrogen gas/ electrons) should be put into the fuel cell to generate the electricity.

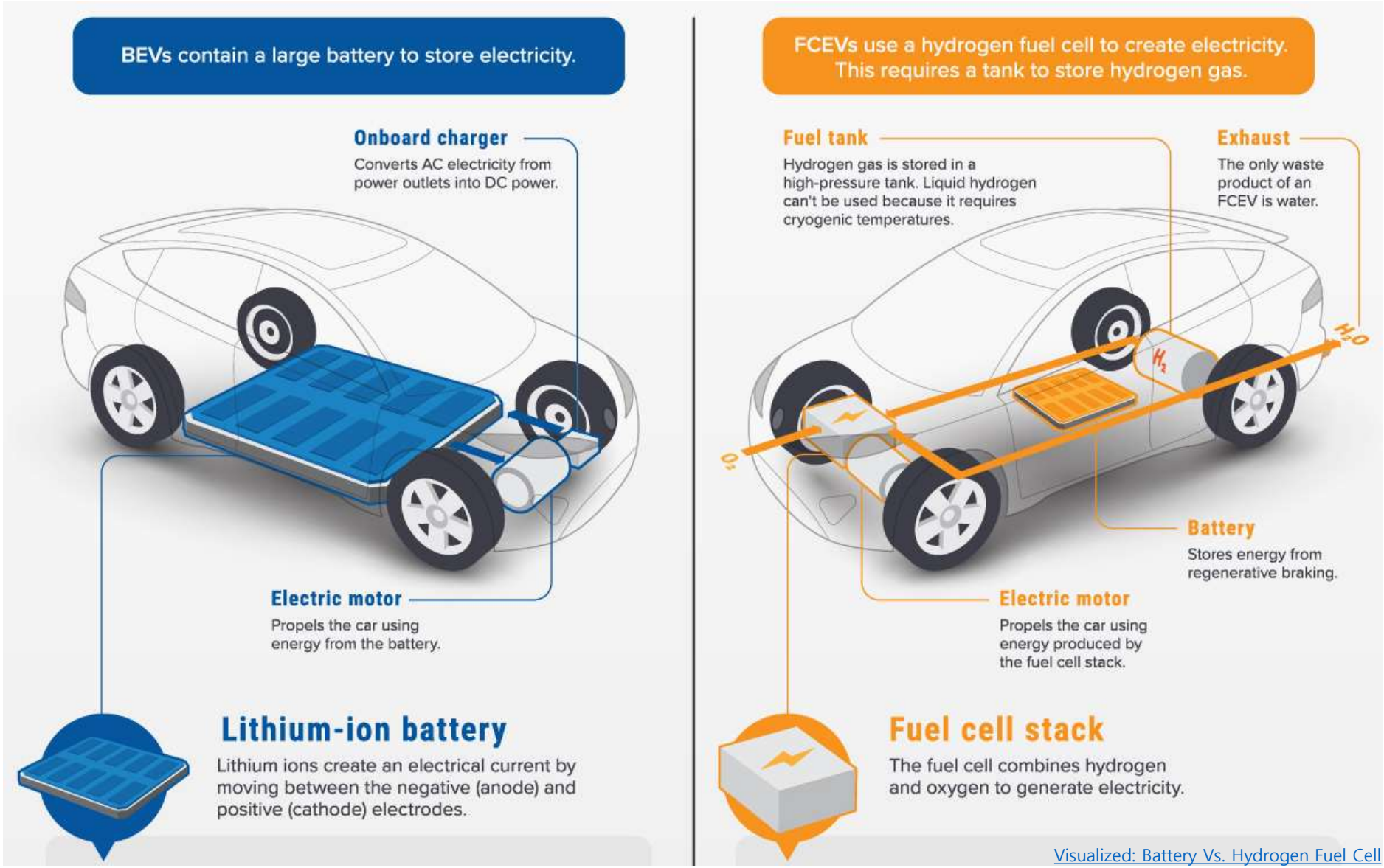
Q9. What is the difference between Electric Vehicle (EV) and Hydrogen car (FCEV) ?

1) Structure.

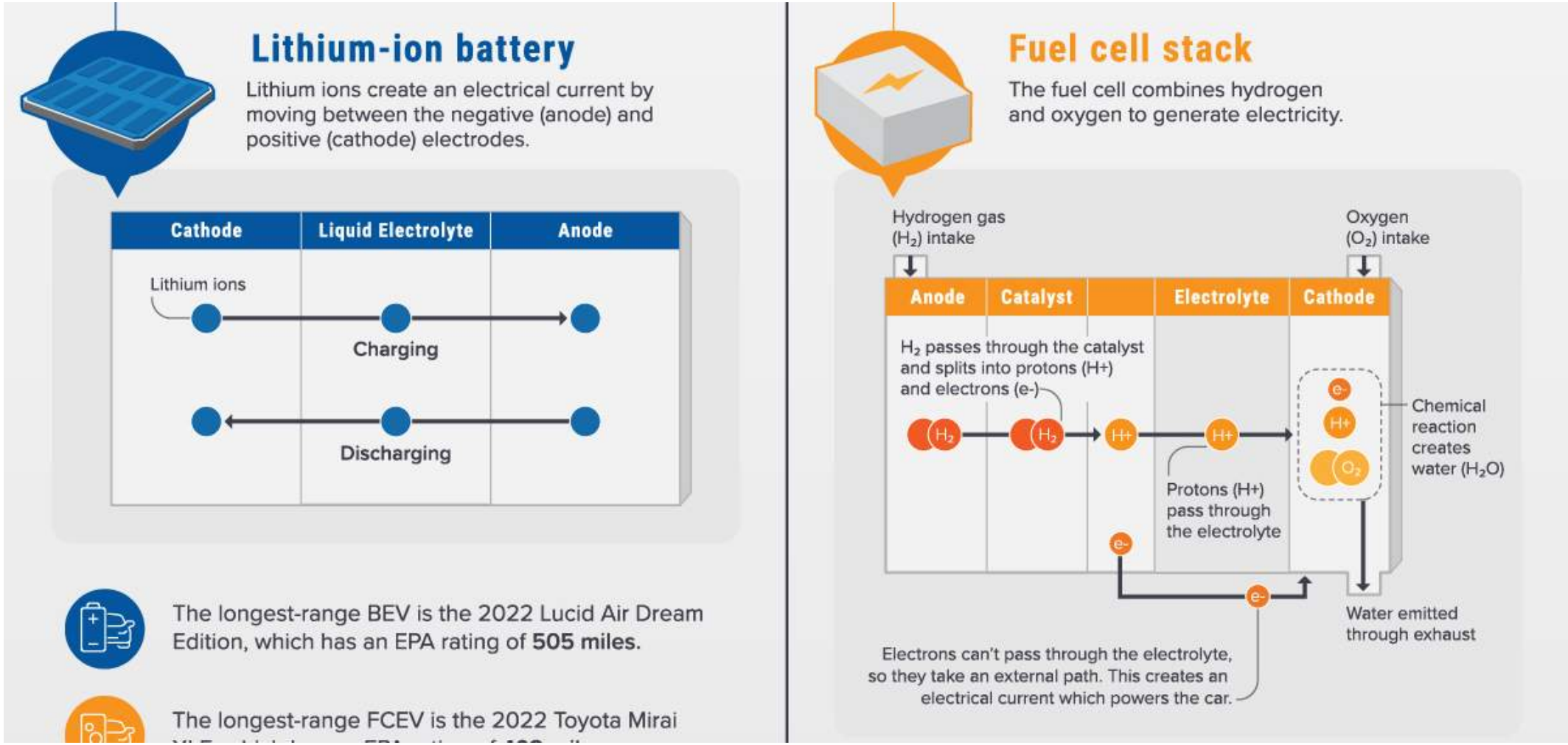
- EV consists of electric motor and battery
- FCEV consists of the electric motor, fuel cell, battery and hydrogen tank

2) Electricity generation

- EV operates the motor from the battery (ex. Lithium-Ion battery), which generates the electron currents from the anode part to the cathode part.
- FCEV runs the electric motor by the electron currents generated from the fuel cell, which extracts the electrons from the hydrogen gas at the anode.
  At the anode, the hydrogen is divided into the electron and hydrogen positive ion (proton) by the catalysts.

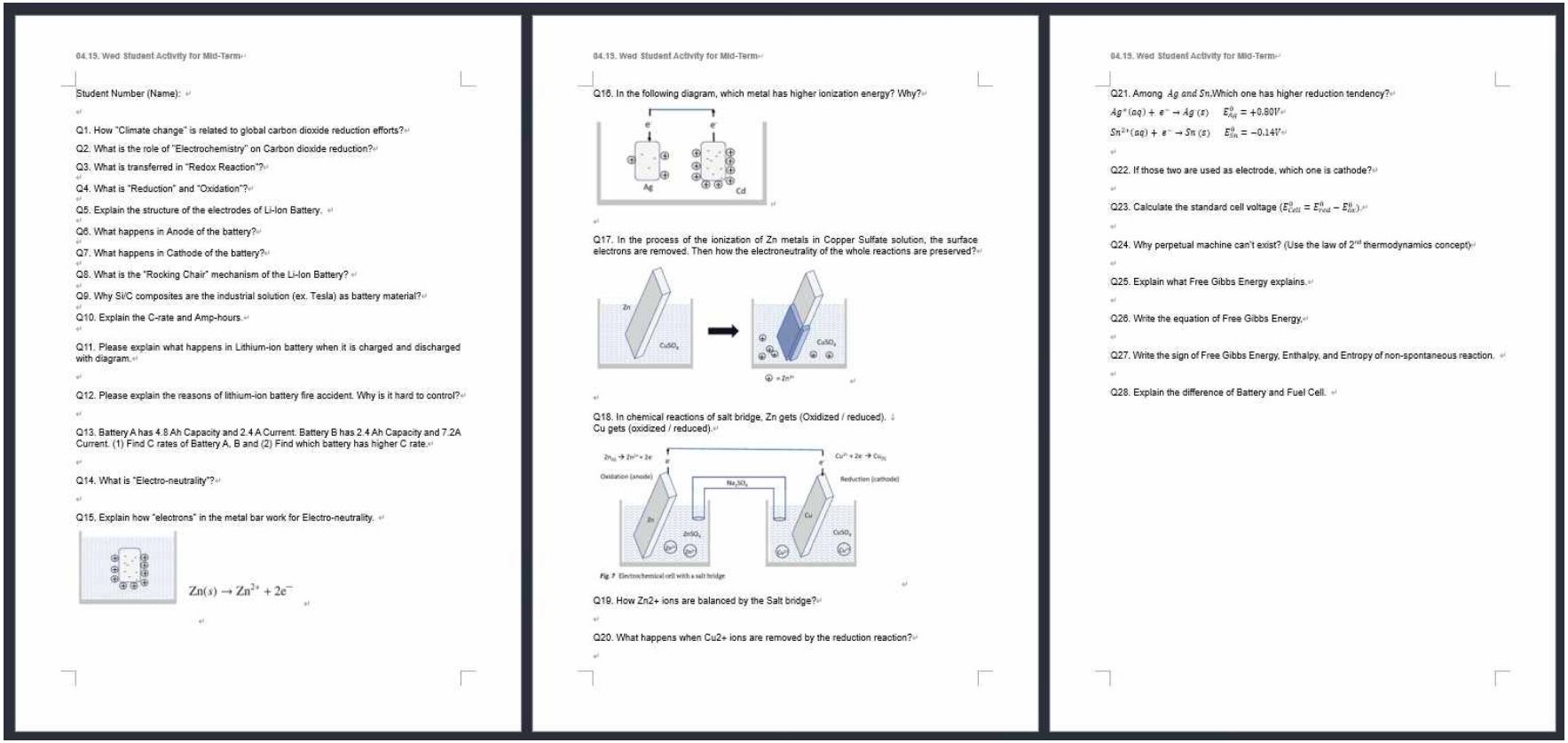


Visualized: Battery Vs. Hydrogen Fuel Cell (visualcapitalist.com)



[Visualized: Battery Vs. Hydrogen Fuel Cell (visualcapitalist.com)]

04.19. Student Activity for MidTerm Prep



04.19. Wed Student Activity for Mid-Term

Student Number (Name):

Q1. How "Climate change" is related to global carbon dioxide reduction efforts?

Q2. What is the role of "Electrochemistry" on Carbon dioxide reduction?

Q3. What is transferred in "Redox Reaction"?

Q4. What is "Reduction" and "Oxidation"?

Q5. Explain the structure of the electrodes of Li-Ion Battery.

Q6. What happens in Anode of the battery?

Q7. What happens in Cathode of the battery?

Q8. What is the "Rocking Chair" mechanism of the Li-Ion Battery?

Q9. Why Si/C composites are the industrial solution (ex. Tesla) as battery material?

Q10. Explain the C-rate and Amp-hours.

Q11. Please explain what happens in Lithium-ion battery when it is charged and discharged with diagram.

Q12. Please explain the reasons of lithium-ion battery fire accident. Why is it hard to control?

Q13. Battery A has 4.8 Ah Capacity and 2.4 A Current. Battery B has 2.4 Ah Capacity and 7.2A Current. (1) Find C rates of Battery A, B and (2) Find which battery has higher C rate.

Q14. What is "Electro-neutrality"?

Q15. Explain how "electrons" in the metal bar work for Electro-neutrality.

$$Zn(s) \rightarrow Zn^{2+} + 2e^{-}$$

04.19. Wed Student Activity for Mid-Term

Q16. In the following diagram, which metal has higher ionization energy? Why?

Q17. In the process of the ionization of Zn metals in Copper Sulfate solution, the surface electrons are removed. Then how the electroneutrality of the whole reactions are preserved?

Q18. In chemical reactions of salt bridge, Zn gets (Oxidized / reduced). Cu gets (oxidized / reduced).

Fig. 7 Electrochemical cell with a salt bridge

Q19. How Zn2+ ions are balanced by the Salt bridge?

Q20. What happens when Cu2+ ions are removed by the reduction reaction?

04.19. Wed Student Activity for Mid-Term

Q21. Among Ag and Sn,Which one has higher reduction tendency?

$Ag^{+}(aq) + e^{-} \rightarrow Ag\ (s) \quad E^{0}_{Ag} = +0.80V$

$Sn^{2+}(aq) + e^{-} \rightarrow Sn\ (s) \quad E^{0}_{Sn} = -0.14V$

Q22. If those two are used as electrode, which one is cathode?

Q23. Calculate the standard cell voltage ($E^{0}_{cell} = E^{0}_{red} - E^{0}_{ox}$).

Q24. Why perpetual machine can't exist? (Use the law of 2nd thermodynamics concept)

Q25. Explain what Free Gibbs Energy explains.

Q26. Write the equation of Free Gibbs Energy.

Q27. Write the sign of Free Gibbs Energy, Enthalpy, and Entropy of non-spontaneous reaction.

Q28. Explain the difference of Battery and Fuel Cell.

04.19. Student Activity for Mid-Term

- The questions are “essential” for the Mid-Term.
- It is the short summary of Student Activity (03.08. – 04.14.)
- The 80% of Mid Term will be from SA (03.08. – 04.14.)
- 20% are from the lecture contents (Lecture 1 – 6)

- **If you submit the 04.19. SA by 21st April, you will get 1:1 feedback during the weekend.**

☞ youjinkim@jbnu.ac.kr

Mid-Term Notice (OFFLINE)

- **04/26 Wed 10:00am – 11:am, Lecture Room 505**
- **No Smart Phone (Please submit it)**
- **Contents**
  - Lecture 1 – 6
  - Student Activities (80%)
  - More than Student Activities (20%)