04.26. Electrochemistry Mid-Term

Name (Student Number) :

Q1. Choose O for the true statement, X for the false statement (40 Points).

(1) Knowledge of electrochemistry is necessary to understand and design energy storage systems, batteries, fuel cells, electrochemical supercapacitors, and hydrogen technologies. (**O** / X)

(2) Fossil fuels are the largest contributor to global climate change, accounting for over 75 per cent of global greenhouse gas emissions. (**O** / X)

(3) Warmer temperatures over time are changing weather patterns and ~~promoting~~ the usual balance of nature. (O / **X**)

(4) Electrochemistry is an interfacial science between chemistry and electricity. (**O** / X)

(5) The electrolyte contains the ions which engage in ~~homogeneous~~ reactions on the electrode surfaces. (O / **X**)

(6) In the “Rocking Chair” mechanism of the Li-ion battery, the electrons ~~move only in one direction~~. (O / **X**)

(7) Lithium-ion batteries can cause a self-sustaining fire. (**O** / X)

(8) The Calendering process is to improve the energy density of the battery. (**O** / X)

(9) Reduction is to lose electrons and oxidation gains the electrons. (O / **X**)

(10) In covalent bonds, the bonds share electrons between the atoms. (**O** / X)

(11) Electroneutrality discourages any processes, which lead to an excessive positive or negative charge. (**O** / X)

(12) In neutral atoms, the positive and negative charges balance each other. (**O** / X)

(13) The electroneutrality of platinum is higher than Zinc. (**O** / X)

(14) The salt bridge is to balance the electroneutrality of ion changes in different solutions (**O** / X).

(15) When the voltmeter is connected to the electrodes, it can measure the ~~absolute potential of the electrode, which is the potential value between the electrode and the solution~~. (O / **X**)

(16) Standard reduction potential sets the raking of the affinity for the reduction elements and compares it with that of ~~oxygen~~. (O / **X**)

(17) In an ~~electrolytic cell~~, the standard reduction potential determines what voltage would be produced. (O / **X**)

(18) When the reaction shows a higher reduction potential, it has a ~~higher~~ ionization tendency. (O / **X**)

(19) When the reaction shows the negative standard reduction potential value, it has a ~~lower~~ ionization tendency than hydrogen reduction. (O / **X**)

(20) Enthalpy measures the ~~heat distribution~~ and Entropy measures the ~~heat flow~~. (O / **X**)

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Q2. Choose the right words or answer the questions (45 Points).

(1)

Lithium-ion battery uses the (electrolyte / inorganic solvent),
which are the leading fire hazard.
The positively charged electrode at the (cathode / anode) contains oxygen,
which can be emitted when the battery is under the stress.

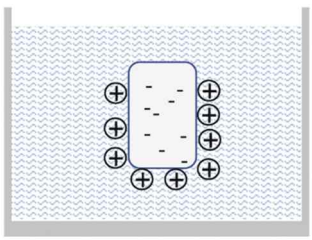
(2)

$$\underset{0}{4\,Fe(s)} + \underset{0}{3\,O_2(g)} \rightarrow \underset{+3\ -2}{2\,Fe_2O_3(s)}$$

In the oxidation process of Fe(s), the oxygen molecules are (reduced / oxidized).

Oxidation involves an (increase / decrease) in the oxidation number of the oxidized molecules.

(3)



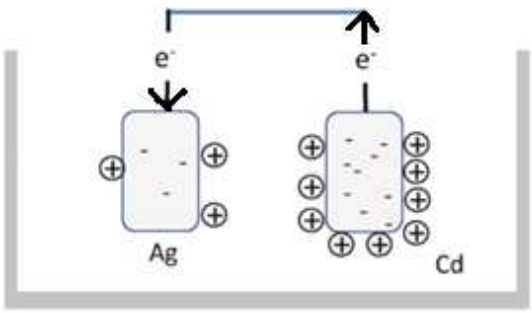
$$Zn(s) \rightarrow Zn^{2+} + 2e^{-}$$

When a zinc metal is immersed in water, the ionization generates the positively charged ions.

The same number of (protons / electrons) remain in the metal.

The ionization process (continues / stops) as the electrons in metal attracts Zn2+.

(4)



In the electrochemical cell with the Ag and Cd electrodes,

The anode is (Ag / Cd).

The cathode is (Ag / Cd).

The anode metal has a (higher / smaller) electroneutrality than the cathode metal.

(5) $Ag^+ + e^- \rightarrow Ag \quad E^0 = +0.80V$

$Fe^{3+} + e^- \rightarrow Fe^{2+} \quad E^0 = +0.77V$

Cell reaction: $Ag^+ + Fe^{2+} \rightarrow Fe^{3+} + Ag$

- What is the standard cell voltage? $E^o_{red} - E^0_{Oxi} = (+0.80V) - (+0.77V) = 0.03V$
- (Ag^+ / Fe^{3+}) has a higher ionization tendency than (Ag^+ / Fe^{3+}).
- Ag^+ and Fe^{3+} have a (higher / smaller) reduction potential than hydrogen.

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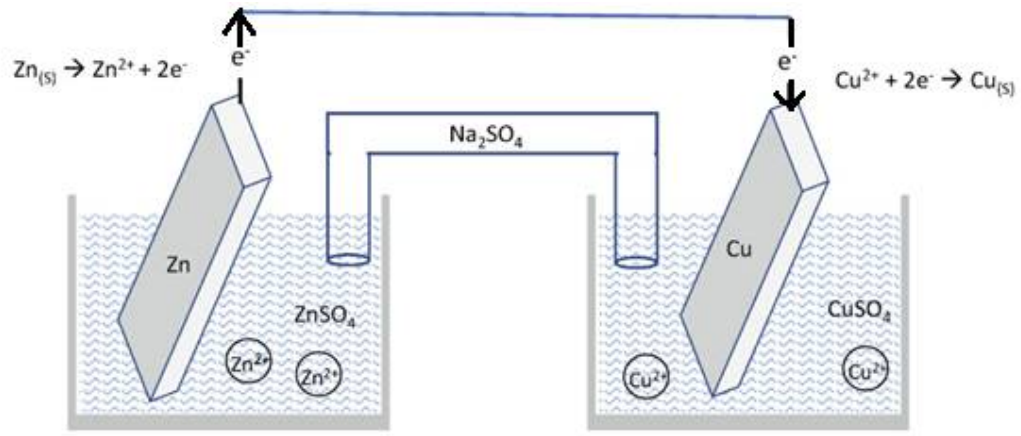
(6)



In the diagram, SO_4^{2-} ions come out from the salt bridge to balance the ion changes of (Zn^{2+} / Cu^{2+}).

When the Cu^{2+} is reduced to form $Cu_{(s)}$, SO_4^{2-} ions come (into / out from) the bridge to preserve the electroneutrality.

(7) When the system gains heat from the surrounding, it is (endothermic / exothermic).

According to Hess's Law, the enthalpy change in a chemical process (is the same / is the summation). It is not dependent on the process, whether it is carried out in one step or several steps.

(8) In the 2nd Law of Thermodynamics, spontaneous reactions always involve (increased / decreased) entropy. Moreover, the perpetual machine can't exist as the energy (can / can not) be converted with 100% efficiency. Low entropy means the energy is (spread / concentrated). High entropy means the energy is (spread / concentrated).

(9) Gibbs free energy explains the spontaneity of the chemical reaction.

Fill the table below with the sign (+) or (-) at each term.

ΔG	=	ΔH	−	$T\Delta S$	
−		−		+	Energetically favorable Entropically favorable Always spontaneous
+		+		−	Energetically unfavorable Entropically unfavorable Never spontaneous

Photosynthesis is a (spontaneous / non-spontaneous) reaction, therefore it has ΔG (> / <) 0.

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Q3. Imagine you buy your car after graduation (15 Points).

You must decide among two options – Battery Electric Vehicles (BEV) or Hydrogen Car (Fuel Cell Electric Vehicles, FCEV).

(1) Decide what you will buy.

(2) Explain why you decide on (1) based on the difference between BEV and FCEV.

(3) Why do EV and FCEV have different structures? (Explain the scientific principle difference between a battery and a fuel cell).

Full point answer should include:

- **Explanation on the scientific difference between Battery and Fuel Cell.**
- **Redox reaction explanation at the cathode and anode part of Battery and Fuel Cell.**
- **Description on the structure difference between BEV & FCEV and correlate them to the difference of Battery and Fuel Cell.**

Ex. The battery (ex. Lithium-Ion battery) generates the electron currents from the anode part, which extracts the electrons from the lithium to the cathode part. The electrons can be put into the battery to charge the lithium ions to be back to the lithium. 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. At the cathode, the electrons, oxygen and hydrogen ions are combined to generate the water.