Fuel Cell Chemistry Questions with Solutions

Q1: What is the difference between the Fuel cell and batteries?

Answer: Batteries make use of metals and their ions or oxides to generate electrical power. Fuel cells require a continuous supply of fuel (considerably hydrogen), and oxygen (from air) to generate electricity. The Fuel cell keeps generating electricity for as long as the fuel is supplied.

Q2. What is an alkaline Fuel cell? What is the other name of Alkaline Fuel cell?

Answer: Alkaline Fuel cell is the most developed fuel cell technology with an efficiency of about 70%. This Fuel cell uses hydrogen and oxygen to produce potable water, heat and electricity. This cell is also known as Bacon Fuel cell.

Q3. Name the different types of Fuel cells.

Answer: There are 6 types of Fuel cells namely:

a. Proton exchange membrane fuel cell (PEMFC)
b. Phosphoric acid fuel cell (PAFC)
c. Solid acid fuel cell
d. Alkaline fuel cell
e. High temperature fuel cell
f. Electric storage fuel cell

Q4. What is the relation between activation energy and reaction time?

Answer: The activation energy is the minimum amount of energy required for the reactants to undergo a chemical reaction. Hence, the activation energy is significantly related to the rate of the reaction as: the higher the activation energy the slower is the reaction.

Q5. What are the major requirements for an electrolyte in a fuel cell?

Answer: The major requirements for an electrolyte in a fuel cell are:

a. The electrolyte must have good water uptake even at high temperatures.
b. It must be resistant and very less permeable to reactant gases.
c. The electrolytes used are solids.
d. The electrolyte must be very much pure in order to protect the catalyst from harmful contamination.

Q6. The heat of combustion of Benzene at constant volume was found to be 3263.9 kJ / mol at 25 °C. Calculate the heat of combustion of Benzene at constant pressure.

Answer: The chemical reaction for the combustion of Benzene is:
C_6H_6 (l) + 15/2 O_2 (g) → 6CO_2 (g) + 3H_2O (l)
In this reaction, the only gaseous reactant and product are oxygen and carbon dioxide respectively.
Hence,
$\Delta n_g = n_p - n_r = 6 - 15/2 = -3/2$
Given ΔU (q_v) = 3263.9 kJ / mol
T = 25 °C= 298 K
R = 8.314 J K^{-1} mol^{-1}
So, ΔH (q_p) = $\Delta U + \Delta n_g RT$ = -3263.9 kJ / mol + (-3/2 mol) (8.314/1000 kJ K^{-1} mol^{-1})(298 K)
= -3267.6 kJ / mol.

Q7. What is a Fuel cell charge transport resistance?

Answer: The Fuel cells generate electrons which are referred to as “charge transport”. Charge transport is the movement of electrons (or charges) from the electrode to the load or where they are used. The difficulty in transport of these charges is called the Fuel cell charge transport resistance. This resistance results in the voltage loss of the Fuel cell. This voltage-loss is called the ohmic loss.

Q8. A Fuel cell is a ___.

a. Galvanic cell
b. Electrolytic cell
c. Electrolytic concentration cells
d. Alkaline Fuel cells

Answer: (a.)

Explanation: Galvanic cells are the electrochemical cells that convert chemical energy into electrical energy.

Q9. Assuming the water vapour a perfect gas, the change in molar enthalpy at 1 bar and 100 °C is 41 kJ mol^{-1}. Calculate the internal energy change for the conversion of 1 mole of water into ice.

Answer: The conversion of water to ice is shown as: H_2O (l) → H_2O (s)
Since in this case, the volume of water changes negligibly, hence,
$\Delta H = \Delta U$ = 41 kJ mol^{-1}.

Q10. Write the cell reaction of Bacon Fuel cell.

Answer: The fuel cells work on two redox reactions between hydrogen and oxygen. The half-cell reactions of the Bacon fuel cell are given below:

1. At anode, the hydrogen is oxidized producing water and electrons as:

$$H_2 + 2OH^- \rightarrow 2H_2O + 2e^-$$

2. At cathode, the electrons produced at the anode return via an external circuit. In this half-cell reaction, the oxygen gets reduced by the incoming electrons and hydroxide ions are produced. The cathode-half reaction is:

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

The electricity and heat are produced as the by-products of these reactions.

Q11. How can we improve the kinetic performance of a fuel cell?

Answer: The kinetic performance of the fuel cells depend upon and thus may be improved by the following:

a. The type of catalyst used during the reaction.
b. The humidity present in the gas.

Q12. What is the heat capacity?

Answer: It is the amount of energy required to raise the temperature of the whole system by 1 ^oC.

Q13. The value of ΔH for endothermic process is

a. Positive
b. Negative
c. Zero
d. None of the above

Answer: (a.)

Explanation: During the endothermic reaction, the heat is absorbed by the reaction if the total heat content of the reactants is less than the total heat content of the products i.e. $H_R < H_P$.
According to the equation $\Delta H = H_P - H_R$, ΔH is positive.

Q14. What is the enthalpy of atomisation?

Answer: The enthalpy change that occurs when 1 mole of a given substance gets dissociated into the gaseous atoms is called the enthalpy of atomisation. It is represented by $\Delta_a H^o$.

Q15. Discuss the major advantages and disadvantages of fuel cells over other power conversion devices.

Answer: The advantages of the Fuel cells include:

a. They leave no pollution when run on pure hydrogen, only pure water and electricity are the products of the reaction.
b. They have higher thermodynamic efficiency than heat engines.
c. They have higher part-load efficiency i.e. if the powerplant size decreases, these cells do not show a sudden drop in the efficiency.
d. The fuel cell systems do not require combustion of fuels to generate electricity.

The disadvantages of fuel cells are:

a. Pure hydrogen is difficult to manufacture and store.
b. Any contaminants such as sulphur and carbon compounds in the fuel may lead to the deactivation of the fuel cell catalyst and thus making the fuel cell unable to operate.
c. For automotive applications, platinum metal is used as a catalyst. Platinum metal is rare and very expensive.
d. Fuel cells require complex control and support systems.

Practise Questions on Fuel Cell

Q1. During the mid-60s period, where did the alkaline fuel cell find their most important utilisation?

Answer: The alkaline Fuel cells were used by NASA in their mid-60s Apollo series space missions to generate power for its satellites and space shuttles.

Q2. What is a Fuel Cell Stack?

Answer: In order to obtain the desired amount of energy, the Fuel cells are often connected in series to generate higher voltage and in parallel connection to generate higher current. This design of connection of Fuel cells to obtain more energy is called Fuel Cell Stack.

Q3. List the technologies for hydrogen storage.

Answer: The common methods used for hydrogen storage are:

a. Compressed hydrogen gas tanks
b. Liquid hydrogen tanks
c. Cryogenic compressed hydrogen
d. Chemical hydrogen storage materials
e. High surface area adsorbent materials

Q4. For the following thermochemical equations:
(i) S (rhombic) + O_2 (g) → SO_2 (g), ΔH = -297.5 kJ / mol

(ii) S (monoclinic) + O_2 (g) → SO_2 (g), ΔH = -300 kJ / mol
Calculate the ΔH of transformation of 1 g atom of rhombic S into monoclinic S.

Answer: To find: S (rhombic) → S (monoclinic), ΔH = ?
From the question, equation (i) - equation (ii) gives S (rhombic) - S (monoclinic) → 0, ΔH = 297.5 - (-300) = 2.5 kJ mol^{-1}.
i.e. S (rhombic) → S (monoclinic), ΔH = + 2.5 kJ mol^{-1}

Q5. Out of E, S, T, P, V, H and G, which are the intensive properties and why?

Answer: Only T and P are the intensive properties because they depend only upon the nature of the substance.