Appendix 3- Reflection questions and assignments

2. Assignment 1.1

The use of fossil fuels is under pressure.

In addition to the intensified greenhouse effect, give two more arguments for switching to alternative sources of energy.

4. Assignment 1.4

Using an atlas (map: distribution of water among rivers and fresh water discharge) find suitable sites in your country for a Blue Energy power plant.

5. Assignment 2.1

One mole of stearic acid (C18H36O2) is burned completely. The volume of a mole of gas ("molar gas volume") at the conditions of the test is 25 dm3. Further, it is given: ΔH = -11 362 kJ mol-1. Assume p = 1x105 N m-2.

If necessary, see Chemistry Block 4 for a repetition of the chemical measure mol.

a. Calculate the change in volume upon combustion.

b. Calculate the volume work involved.

c. Calculate the percentage difference between ΔE and ΔH in this combustion.

7. Assignment 2.2

a. What is the entropy increase (ΔS) if we heat 12 g of oxygen from 80 K to 180 K at standard pressure? Use Figure 11 for this purpose.

b. We heat at standard pressure 1 mole of oxygen and 1 mole of water from 220 K to 400 K. The entropy increase of water appears to be much greater than that of O2. Give an explanation for this.

8. Assignment 2.2

Reason about whether entropy decreases or increases with the following processes:

a. $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

b. $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

c. $H_2O(l) \rightarrow H_2O(g)$

d. $N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$

9. Assignment 2.3

When we mix a solution of silver nitrate with a solution of iron(II) sulfate, the following equilibrium sets in:

$Ag^{+}(aq) + Fe^{2+}(aq) \leftrightarrows Ag(s) + Fe^{3+}(aq)$

Using the concept of entropy, reason whether the enthalpy effect for the reaction to the right is positive or negative.

11. Assignment 2.3

In green plants, under the influence of sunlight, glucose is made from carbon dioxide and water (photosynthesis).

$6\ CO_2(g) + 6\ H_2O(l) \rightarrow C_6H_{12}O_6(s) + 6\ O_2(g)$

a. Calculate the reaction enthalpy of this process. Hint: look at the reverse process.

b. Calculate the entropy change during this process. The absolute entropy of glucose

13. Assignment 2.4

Salt and fresh water spontaneously mix to form "brackish" water. When mixing one liter of fresh water with one liter of salt water, the temperature change is negligible.

a. What does this mean for the mix enhalpy ΔH?

b. What causes (according to which rule(s)) fresh and salt water to mix?

14.1 Assignment 2.4: Model 1

In this assignment, you will assume Model 1. In this model, 1 liter of river water mixes with infinitely many liters of seawater.

a. How many moles of water does the liter of river water contain?

b. In Model 1, what is the initial concentration of table salt of river water and what is the final concentration of the mixture obtained (both in mol L-1)? For this, make a good assumption about the molarity of the salt in the seawater.

c. Determine the entropy change (in J mol-1K-1) from Figure 13.

d. Calculate TΔS in that liter of river water (T = 15 oC).

e. According to this model, how much energy (in kJ) is lost when 1 liter of river water flows out to sea? Enter this in the table in Figure 14

f. In the Netherlands, an average of 3.3 million liters of fresh water per second flows out to sea. How much power (in MW) is lost with this (according to model 1)? Fill this in in the table of Figure 14.

14.2 Assignment 2.4: Blue Energy versus running water

In this assignment, you will compare the energy from Blue Energy that you calculated in assignment 14.1 with the energy that can be generated from running water.

a. When water falls down (for example, in a waterfall), energy is also lost. Calculate the distance over which a liter of water would have to fall down to "lose" the same amount of energy as when river water flows into the sea (answer question 14.1d). See physics block 3 if necessary.

b. For the Netherlands, calculate how much energy is lost when a liter of river water flows from Lobith to Hoek van Holland and calculate the total energy loss of flowing river water in the Netherlands. Enter your answers in the table in Figure 14.

c. Using the answer from question 14.2a, calculate the osmotic pressure difference between river water and seawater.

Energysupplier	kJ L^{-1}	Possible delivered capacity for the Netherlands (MW)
a. Blue Energy	(assignment 14.1c)	(assignment 14.1d)
b. Hydropower	(assignment 14.2b)	(assignment 14.2b)

Figure 14: comparison hydropower and Blue Energy.

14.3 Assignment 2.4: Model 2

You're going to do the calculation of assignment 14.1 with Model 2 more precisely. So the main difference is that you are working with real volume ratios between river and sea water.

a. Suppose we mix 1 liter of seawater and 1 liter of river water at the plant. What will be the concentration in the mixed water, cm?

b. How large is ΔE? Compare your answer with assignment 14.1c.

c. Complete the table in Figure 15. Always calculate cm first and determine which ratio is best for a Blue Energy power plant.

V_r (m^3)	V_z (m^3)	*W* (MJ m^{-3} river water)	*W* (MJ m^{-3} mixed water)	Opmerking
1	∞			see 14.1c
1	2			
1	1			see 14.3b
2	1			
∞	1			Take for ∞ a big number

∞ = oneindig

Figure 15: mixing energy at different mixing ratios.

15. Assignment 3.2

Reason about whether the particles below can take in electrons or give up electrons. Which particles can do both?

H^+, Al, Mg^{2+}, K, O_2, Fe^{2+}, I_2, Br_2 en Cl^-.

16. Assignment 3.2

Find out if electron transfer occurs in the following processes. Compile a reaction equation for each of the reactions and state how any electron transfer occurs.

a. potassium + iodine → potassium iodide

b. nickel + bromine → nickel bromide

c. silver + sulfur → silver sulfide

17. Assignment 3.2

Via half-reactions, set up the reaction equations for the following reactions:

a. copper with oxygen

b. aluminum with iodine

c. chlorine with aluminum iodide solution

d. nickel with cobalt(II) chloride solution

e. calcium and water

19. Assignment 3.2

Calculate V_{bron} of the following cells and indicate the negative electrode.

a. zinc-tin cell

b. aluminum-silver cell

c. copper-silver cell

20. Assignment 3.2

Of a standard manganese-lead cell, the source voltage is 0.90 volts. When current is supplied by this cell, the manganese rod goes into solution.

a. Give the equations of both half-reactions that occur during current delivery. Explain which electrode is positive and which is negative.

b. Calculate V0 of the redox couple Mn_2^+/Mn.

21. Assignment 3.2

a. Calculate the source voltage of an electric cell consisting of two copper electrodes, where [Cu^{2+}(aq)] in one half-cell is 1.0 M and in the other half-cell is 10^{-4} M.

b. Which electrode is (+) and which is (-)?

c. How does the electron flow when the cell is closed?

22. Assignment 3.2

a. Calculate the source voltage of an electrochemical cell consisting of a standard copper half-cell and a magnesium half-cell, where [Mg^{2+}(aq)] = 0.10 M.

b. Explain that you cannot say that at a concentration less than 1.0 molar of a metal solution, the source voltage always increases.

23. Assignment 3.2

At the beginning of this chapter are four ways to convert concentration differences into useful forms of energy:

a. Explain in which direction Katchalsky's system rotates: clockwise or counterclockwise?

b. Explain where at VPDU the vapor pressure is higher: above the freshwater or above the saltwater?

c. Explain how high at PRO the back pressure is placed on the salt water. Use the answer from assignment 14.2c.

d. Write down the redox reaction at RED, explaining that the sum of the electrode potentials (at equal concentrations of Fe^{2+} and Fe^{3+}) is zero.

24.1 Assignment 3.2 RED

Answer 23d shows that the operation of RED differs from that of a Daniell cell. Yet even with RED, there is a voltage difference at the electrodes. You are going to look at where that difference comes from and how large it is.

a. Copy Figure 23. Indicate with arrows how the mixing takes place and give a brief explanation. What is the "driving force" behind the mixing?

b. Calculate the membrane potential for seawater containing 30 g NaCl L^{-1} and river water containing 1 g NaCl L^{-1}.

c. Make a similar picture for an anion-exchanging membrane. Indicate with arrows how mixing occurs, noting the redox reactions and the direction of electron flow.

d. Calculate the Nernst potential for the anion-exchanging membrane.

e. Explain how the potential of the anion exchange membrane changes when seawater and river water are exchanged.

24.2 Assignment 3.2 RED

In a RED, anion exchange membranes and cation exchange membranes are stacked alternately between alternating layers of seawater and river water. Consider the RED setup in Figure 20.

a. The inner membranes (11 pieces) are placed between seawater and river water. What is the combined voltage of these membranes?

The two outer membranes are special. They are placed on one side between the electrode rinse fluid and river water, and on the other side between seawater and the electrode rinse fluid. These outer membranes count together as a single one:

In this derivation, the subscript e represents the electrode rinse fluid.

b. What is the stack voltage of the RED in Figure 20?

c. What is the stack voltage of a RED system with N stacked membranes?

Figure 20 also shows how the electrode fluid is pumped around.

d. Explain whether Vbron would remain zero if the pumping around did not occur.

e. Why does one always stack an odd number of membranes? Hint: consider what would happen to the electrode fluid otherwise.

25. Assignment 4.1

In Chapter 3, we assumed a RED to which a voltmeter was connected, not an electrical device. We call this situation 'open circuit'. The same situation occurs when a 'device' is connected with an infinite resistance R_u.

a. What is the magnitude of the current indicated by the ammeter?

b. What is the stack voltage U that the voltmeter indicates?

c. What is the power P?

26. Assignment 4.1

Suppose we connect the electrodes to a live wire, but we forget to connect a device. We call this situation: short circuit (shorted circuit). This corresponds to a connected device whose resistance R_u is zero.

a. What is the amperage indicated by the ammeter?

b. What is the stack voltage U that the voltmeter indicates?

c. What is the power P?

27. Assignment 4.1

In the two extreme situations, open circuit (question 25) and short circuit (question 26), no power is made. in fact, in the case of short circuit, all electrical energy is lost. We now consider a situation where a real device is connected.

a. What is the magnitude of the current indicated by the ammeter?

b. What is the stack voltage U indicated by the voltmeter?

c. Derive the power P as a function of Ri and show that the maximum power is delivered when R_u of the device is equal to the internal resistance R_i.

28. Assignment 4.2

In this assignment, T = 293 K is always T.

a. A copper wire with a cross section of 2.5 mm^2 has a resistance of 14 Ω. Calculate the wire length.

b. An iron wire with a length of 200 m has a resistance of 7 ohms. Calculate the cross section (mm^2).

c. A wire with a cross section of 2.5 mm^2 and length 20 m has a resistance of 3.5 Ω. What material is this wire possibly made of?

d. What is the conductivity ($S\ m^{-1}$) of platinum?

29.1 Assignment 4.2 Internal resistance stack

To calculate the power of the stack in Figure 20, first calculate the internal resistance R_i. Assume 1 m^2 for the area of each membrane and 0.5 mm for the distance between the membranes. The other details of the membranes are given in the text.

a. What is the resistance of a cation exchange membrane (R_{CEM})?

b. What is the resistance of an anion-exchanging membrane (R_{AEM})?

c. What is the resistance of a layer of seawater (R_z)?

d. What is the resistance of a layer of river water (Rr)?

e. So which of the above partial resistances makes the largest contribution to the total resistance?

f. What is the total resistance of the stack (R_i)?

29.2 Assignment maximum power stack

You can calculate the maximum power output of the stack in Figure 20 using the OCV (assignment 24.2c) and the internal resistance (assignment 29.1f). Use the equation you derived in question 27c.

a. What is the maximum power generated *P*?

b. What is the specific power *p*?

c. At least how many square kilometers of membrane area do you need for a 200 MW power plant (such as could be built on the Afsluitdijk, for example)?

d. In practice, up to 6,000 membranes are stacked. How many square meters of land area is then needed for 200 MW?