Workshop P6: Corrosion and Sustainability

LEARNING OUTCOMES

- Understand the concept of oxidation and reduction reactions
- Use standard electrode potential to predict the potential for corrosion
- Embodied energy and carbon footprint

Activity 1: Will this metal react with dilute sulphuric acid? (20 minutes)

The standard electrode potential is the maximum voltage in an electrochemical cell of a metal/metal ion electrode is coupled to a hydrogen electrode under standard conditions.

Enter your initials in the box, and the metal relevant to your initials will be displayed:

Initial 1	Initial 2	Metal
D	Q	Sn

By using the standard reduction potential E_0, make a prediction as to whether or not your metal reacts with dilute sulphuric acid, using the *Data Sheet for Table of standard electrode potentials*. Write both half-reactions, and the redox reaction, to show how you came to your conclusion.

Metal	Sn
$Sn^{2+} + 2e^- \rightarrow Sn \quad E_0 = -0.14V$ ① $2H^+ + 2e^- \rightarrow H_2(g) \quad E_0 = 0V$ ② ② − ①: $Sn + 2H^+ \rightarrow Sn^{2+} + H_2 \quad E_0 = 0.14V$	
Reacts?	**Yes/No**

Activity 2: Predicting and preventing corrosion (30 minutes)

An old wooden sailboat is held together with iron screws, and has a bronze propeller (copper alloy containing 7-10% tin). Using the E_0 values are given in the Table, answer the following:

(a) Write down the half-reactions for the oxidation (corrosion) of each metal.

$Fe(s) \rightarrow Fe^{2+} + 2e^- \quad E_0 = 0.44$

$O_2(g) + 4H^+ + 4e^- \rightarrow 2H_2O(l) \quad E_0 = 1.23$

$2Fe + O_2 + 4H^+ \rightarrow 2Fe^{2+} + 2H_2O \quad E_0 = 1.67$

(b) If the boat is immersed in seawater, with iron screws in contact with the bronze propeller, predict which corrosion reaction will occur, based on your part (a). Assume the cathodic reaction is #5. Write both half reactions, and the redox reaction, to show how you came to your conclusion.

As per prior discussion, the cathodic reaction is as below

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

The half reaction on anodic side is as below

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

overall reaction is as below

$2Fe(s) + O_2(g) + 4H^+(aq) \rightarrow 2Fe^+(aq) + 2H_2O(l)$

$Cu(s) \rightarrow Cu^{2+} + 2e^-$ $(-0.34 + 1.23 = 0.89)$

$Sn^{2+} + 2e^- \rightarrow Sn(s)$ $(0.14 + 1.23) = 1.37$

Activity 3: Mobile phone energy and emissions (30 minutes)

The *embodied energy* of a mobile phone is approximately 400 MJ. When charging, the charger consumes about 1 Watt. If the phone is used for 2 years, and is charged for 4 hours every night, calculate:

USAGE based on energy supplied by power plant of 38% efficiency	
Consumer usage energy (MJ)	$2 \times 365 \times 4 = 2920$ hrs $2920 \times 60 \times 60 = 10.512 \times 10^6$ sec 10.512×10^6 sec $\times$ 1 J/sec $= 10.512 \times 10^6$ J
Actual energy required (MJ)	$(400 + 10.5) \times 10^6$ J $= 410.5 \times 10^6$ J → total energy requirement $38\% = \frac{410.5 \times 10^6}{\text{actual energy}}$ → actual energy $= 1080.3$ J

Discuss with your group how many years you might wait to swap your phone for a new one.

The mobile phones are manufactured in Shanghai, China, and transported to Perth, Australia. The distance from Shanghai to Perth by sea is approximately 8878 km, and direct flights travel 7040 km, and takes 11 hr 30 min. The carbon footprint for transport is given below:

Transport type	Carbon footprint (kg CO_2/tonne.km)
~~**Shipping - diesel**~~	0.015
Aircraft, long-haul - kerosene	0.53
Aircraft, short-haul - kerosene	0.9

If the phones are shipped in lots of 10,000, what is the carbon footprint per shipment?

Mass of a mobile phone (g)	*(first 3 digits of your student ID)*
CO_2 emissions (kg)	
By Sea	total weight: 210g/1000 = 0.21kg; 0.21kg × 10000 = 2100kg; 2100kg / 1000 = 2.1 tonnes Carbon emissions = 0.015kg (CO_2) / tonne·km = kg (CO_2) / 8878km × 2.1 tonnes 0.015kg (CO_2) / tonnes km = kg (CO_2) / 18643.8km × tonnes CO_2 emissions = 279.66kg (CO_2)
By Air	0.53kg (CO_2) / tonne·km = kg (CO_2) / 7040km × 2.1 tonnes 0.53kg (CO_2) / tonnes·km = kg (CO_2) / 14784km·tonnes CO_2 emissions = 7835.52 kg (CO_2)

Activity 4: Life Cycle Energy Costs (20 minutes)

The following bar chart and individual column charts show the relative lifetime energy costs for the following products. Match each chart (A-F) with the correct product, *using the Data Sheet provided*. All energy values are in MJ.

ITEM	Choose graph	Reasoning
Washing machine (40°C wash cycles)	A or B	graph B is more cost efficient
Unheated building (per m^2, life of 25 years)	A or B	because the use of heating in graph A is very less compared to graph
Smart phone	C or D	manufacturing cost in graph D is very less compare to graph B
Bottled water (per 100 bottles)	C or D	disposal amount is very less in graph C compared to in graph A
Family car (per 1000 passenger.km)	E or F	because transport of car is very less in graph E compared to graph F
Electric kettle (3 year life span)	E or F	Because use of electric keetle is less in graph F compared to graph E