PiXL Independence:

Chemistry – Student Booklet

KS5

Electrode potentials and electrochemical cells

Contents:

PiXL Independence – Level 1
Multiple Choice Questions
A Level Chemistry – Electrode potentials and electrochemical cells

INSTRUCTIONS **Score: /20**

- **Read the question carefully.**
- **Circle the correct letter.**
- **Answer all questions.**

1. Which of the following statements about oxidation is FALSE?
   a. Loss of electrons.
   b. The addition of oxygen or loss of hydrogen.
   c. Gaining electrons.
   d. An increase in oxidation number.

2. Which of the following is not a standard condition used when measuring the standard electrode potential?
   a. 1.00 mol dm^{-3}
   b. Pt electrode
   c. 100kPa
   d. 298K

3. Standard electrode potentials are measured when connected to…
   a. nothing.
   b. a standard hydrogen electrode.
   c. a salt bridge.
   d. a Pt electrode.

4. Look at the following equations for two half cells, with their standard electrode potentials:

$$Br_{2(aq)} + 2e^- \rightleftharpoons 2Br^-_{(aq)} \quad E^\theta = +1.07$$
$$Fe^{3+}_{(aq)} + e^- \rightleftharpoons Fe^{2+}_{(aq)} \quad E^\theta = +0.77$$

Which of the following cell diagrams follows the conventional representation of half cells?

a.	$2Br^-_{(aq)}$	$Br_{2(aq)}$	$Fe^{3+}_{(aq)}$	$Fe^{2+}_{(aq)}$
b.	$Br_{2(aq)}$	$2Br^-_{(aq)}$	$Fe^{3+}_{(aq)}$	$Fe^{2+}_{(aq)}$
c.	$Fe^{2+}_{(aq)}$	$Fe^{3+}_{(aq)}$	$Br_{2(aq)}$	$2Br^-_{(aq)}$
d.	$Fe^{2+}_{(aq)}$	$Fe^{3+}_{(aq)}$	$2Br^-_{(aq)}$	$Br_{2(aq)}$

5. Look at the following equations for two half cells, with their standard electrode potentials:

$$Mg^{2+}_{(aq)} + 2e^- \rightleftharpoons Mg_{(s)} \quad E^\theta = -2.37$$
$$Fe^{3+}_{(aq)} + e^- \rightleftharpoons Fe^{2+}_{(aq)} \quad E^\theta = +0.77$$

Which of the following cell diagrams follows the conventional representation of half cells?

a.	$Fe^{2+}_{(aq)}$	$Fe^{3+}_{(aq)}$	$Mg_{(s)}$	$Mg^{2+}_{(aq)}$
b.	$Fe^{3+}_{(aq)}$	$Fe^{2+}_{(aq)}$	$Mg^{2+}_{(aq)}$	$Mg_{(s)}$
c.	$Mg^{2+}_{(aq)}$	$Mg_{(s)}$	$Fe^{3+}_{(aq)}$	$Fe^{2+}_{(aq)}$
d.	$Mg_{(s)}$	$Mg^{2+}_{(aq)}$	$Fe^{3+}_{(aq)}$	$Fe^{2+}_{(aq)}$

6. Calculate the standard cell potential (e.m.f.) of this cell using the following information:

$$Mg^{2+}_{(aq)} + 2e^- \rightleftharpoons Mg_{(s)} \quad E^\theta = -2.37$$
$$Fe^{3+}_{(aq)} + e^- \rightleftharpoons Fe^{2+}_{(aq)} \quad E^\theta = +0.77$$

   a. 3.14
   b. -3.14
   c. 2.40
   d. -2.40

7. Calculate the standard cell potential (e.m.f.) of this cell using the following information:

$$Br_{2(aq)} + 2e^- \rightleftharpoons 2Br^-_{(aq)} \quad E^\theta = +1.07$$
$$Fe^{3+}_{(aq)} + e^- \rightleftharpoons Fe^{2+}_{(aq)} \quad E^\theta = +0.77$$

   a. -1.84
   b. 0.30
   c. 1.84
   d. -0.30

8. Using the following data, determine which reaction below is NOT feasible.

$$Mg^{2+}_{(aq)} + 2e^- \rightleftharpoons Mg_{(s)} \quad E^\theta = -2.37$$
$$Zn^{2+}_{(aq)} + 2e^- \rightleftharpoons Zn_{(s)} \quad E^\theta = -0.76$$
$$Sn^{4+}_{(aq)} + 2e^- \rightleftharpoons Sn^{2+}_{(aq)} \quad E^\theta = -0.25$$
$$Cu^{2+}_{(aq)} + 2e^- \rightleftharpoons Cu_{(s)} \quad E^\theta = +0.34$$
$$Fe^{3+}_{(aq)} + e^- \rightleftharpoons Fe^{2+}_{(aq)} \quad E^\theta = +0.77$$

   a. Mg and Zn^{2+}
   b. Fe^{3+} and Sn^{2+}
   c. Fe^{2+} and Cu^{2+}
   d. Zn and Cu^{2+}

9. Which of the following statements, about electrochemical cells, is FALSE?
   a. Electrons flow from the more reactive metal to the less reactive metal.
   b. The reactions happening at the electrodes are not reversible.
   c. The solutions are connected by a salt bridge.
   d. It is a redox process.

10. Which of the following statements is TRUE?
   a. A metal that is easy to oxidise has a very negative electrode potential.
   b. The direction of a reaction in a cell depends upon how easily each metal loses electrons.
   c. Electrode potentials are measured against a standard hydrogen electrode.
   d. The standard electrode potential is the resistance measured under standard conditions when the half-cell is connected to a standard hydrogen electrode.

11. An electrochemical cell containing a magnesium half-cell and a tin half-cell, connected by a salt bridge and wires, was set up.

$$Mg^{2+}_{(aq)} + 2e^- \rightleftharpoons Mg_{(s)} \quad E^\theta = -2.37$$
$$Sn^{4+}_{(aq)} + 2e^- \rightleftharpoons Sn^{2+}_{(aq)} \quad E^\theta = -0.25$$

What is the overall equation for the reaction?

a. $Mg_{(s)} + Sn^{4+}_{(aq)} \rightleftharpoons Mg^{2+}_{(aq)} + Sn^{2+}_{(aq)}$
b. $Mg^{2+}_{(aq)} + Sn^{4+}_{(aq)} \rightleftharpoons Mg_{(s)} + Sn^{2+}_{(aq)}$
c. $Mg_{(s)} + Sn^{2+}_{(aq)} \rightleftharpoons Mg^{2+}_{(aq)} + Sn^{4+}_{(aq)}$
d. $Mg^{2+}_{(aq)} + Sn^{2+}_{(aq)} \rightleftharpoons Mg_{(s)} + Sn^{4+}_{(aq)}$

12. An electrochemical cell containing a magnesium half-cell and a tin half-cell, connected by a salt bridge and wires, was set up.

$$Mg^{2+}_{(aq)} + 2e^- \rightleftharpoons Mg_{(s)} \quad E^\theta = -2.37$$
$$Sn^{4+}_{(aq)} + 2e^- \rightleftharpoons Sn^{2+}_{(aq)} \quad E^\theta = -0.25$$

Which metal is reduced in this cell?

a. Magnesium
b. Tin
c. Neither
d. Both

13. Which of the following equations is used to calculate the standard cell potential?

a. $E^\theta_{cell} = E^\theta_{reduced} + E^\theta_{oxidised}$
b. $E^\theta_{cell} = E^\theta_{reduced} - E^\theta_{oxidised}$
c. $E^\theta_{cell} = E^\theta_{oxidised} - E^\theta_{reduced}$
d. $E^\theta_{cell} = E^\theta_{oxidised} + E^\theta_{reduced}$

14. Which of the following statements is FALSE?

a. Zn is oxidised to form Zn^{2+}
b. Zn loses electrons to form Zn^{2+}
c. When Zn is placed in an electrochemical cell with Cu^{2+} the Cu^{2+} ions are reduced.
d. In an electrochemical cell electrons flow through the wire from the less reactive metal to the more reactive metal.

15. What is the conventional representation of the cell used to measure the standard electrode potential for the Mg^{2+} / Mg electrode?

a.	Pt	$Mg^{2+}_{(aq)}$	$Mg_{(s)}$	$H_{2(g)}$	$2H^{2+}_{(aq)}$
b.	Pt	$Mg^{2+}_{(aq)}$	$Mg_{(s)}$	$2H^{+}_{(aq)}$	$H_{2(g)}$
c.	Pt	$H_{2(g)}$	$2H^{2+}_{(aq)}$	$Mg_{(s)}$	$Mg^{2+}_{(aq)}$
d.	Pt	$H_{2(g)}$	$2H^{2+}_{(aq)}$	$Mg^{2+}_{(aq)}$	$Mg_{(s)}$

16. What is the standard electrode potential for the following?

$$2H^{+}_{(aq)} + 2e^- \rightleftharpoons H_{2(g)}$$

a. +1.00
b. 0.00
c. -1.00
d. -0.13

17. In which of the following substances does chlorine have an oxidation number of +5?
    a. $NaClO_3$
    b. $NaClO_4$
    c. $NaClO_2$
    d. NaClO

18. In which of the following substances does manganese have an oxidation of +4?
    a. Mn_2O_3
    b. Mn_2O_7
    c. MnO_2
    d. MnO

19. Look at the following information for an electrochemical cell:

$$Mg^{2+}_{(aq)} + 2e^- \rightleftharpoons Mg_{(s)} \quad E^\theta = -2.37$$
$$Cu^{2+}_{(aq)} + 2e^- \rightleftharpoons Cu_{(s)} \quad E^\theta = +0.34$$

    Which of the following is TRUE?
    a. $Cu_{(s)} + Mg^{2+}_{(aq)} \rightleftharpoons Cu^{2+}_{(aq)} + Mg_{(s)}$
    b. The E^θ of the cell is -2.7.
    c. Magnesium has been oxidised.
    d. $Mg^{2+}_{(aq)} \mid Mg_{(s)} \parallel Cu_{(s)} \mid Cu^{2+}_{(aq)}$

20. What is the oxidation number of Sulphur in $Na_2S_2O_3$?
    a. +4
    b. +2
    c. +1
    d. -2

PiXL Independence – Level 2
5 questions, 5 sentences, 5 words
A Level Chemistry – Electrode potentials and electrochemical cells

INSTRUCTIONS

- **For each statement, use either the suggested website or your own text book to write a 5-point summary. In examinations, answers frequently require more than 1 key word for the mark, so aim to include a few key words.**
- **It is important to stick to 5 sentences. It is the process of selecting the most relevant information and summarizing it, that will help you remember it.**
- **Write concisely and do not elaborate unnecessarily, it is harder to remember and revise facts from a big long paragraph.**
- **Finally, identify 5 key words that you may have difficulty remembering and include a brief definition. You might like to include a clip art style picture to help you remember it.**

Example:

QUESTION:	**What is a redox reaction?**
Sources:	**Website –** http://www.s-cool.co.uk/a-level/chemistry/electrochemistry/revise-it/redox-reactions **Website –** https://www.chemguide.co.uk/inorganic/redox/equations.html **Website –** http://www.chemguide.co.uk/inorganic/redox/oxidnstates.html

1. **Oxidation is the loss of electrons; e.g.** $Mg_{(s)} \longrightarrow Mg^{2+}_{(aq)} + 2e^-$
2. **Reduction is the gain of electrons; e.g.** $Cu^{2+}_{(aq)} + 2e^- \longrightarrow Cu_{(s)}$
3. **Redox reactions involve both oxidation and reduction. The half equations can be combined to illustrate a redox reaction e.g.** $Mg_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Mg^{2+}_{(aq)} + Cu_{(s)}$
4. **For oxidation, there is an increase in oxidation number; for reduction, a decrease in oxidation number.**
5. **Oxidation numbers can be used to identify what has been oxidised and what has been reduced in a reaction.**

OIL	**RIG**	**Redox = OIL and RIG**	**↑ Oxidation no. = O** **↓ Oxidation no. = R**	**Oxidation no. identifies O or R**

QUESTION 1:	**What is meant by the term 'Standard Electrode Potential'?**
Sources:	**Website –** https://en.wikipedia.org/wiki/Standard_electrode_potential **Website –** http://hyperphysics.phy-astr.gsu.edu/hbase/Chemical/electrode.html

QUESTION 2:	**Explain how the Standard Electrode Potential is measured.**
Sources:	**Website –** http://www.chemguide.co.uk/physical/redoxeqia/introduction.html **Website –** http://www.s-cool.co.uk/a-level/chemistry/electrochemistry/revise-it/standard-electrode-potential

QUESTION 3:	**Explain how a fuel cell generates voltage.**
Sources:	**Website –** http://americanhistory.si.edu/fuelcells/basics.htm#q2 **Website –** https://auto.howstuffworks.com/fuel-efficiency/alternative-fuels/fuel-cell.htm

QUESTION 4:	Describe the risks and benefits of fuel cells.
Sources:	**Website –** http://www.fuelcelltoday.com/about-fuel-cells/benefits **Website –** https://thenextgalaxy.com/10-disadvantages-and-advantages-of-hydrogen-fuel-cells/

QUESTION 5:	Explain how to predict the feasibility of a reaction using Standard Electrode Potentials.
Sources:	**Website –** https://www.chemguide.co.uk/physical/redoxeqia/predict.html **Website –** http://www.knockhardy.org.uk/sci_htm_files/08e0.pdf

PiXL Independence – Level 3
Science in the News
A Level Chemistry – Electrode potentials and electrochemical cells

Fake news

Sensationalised news stories have been around for some time, but with the mass growth of social media, the problem seems to have grown in recent years.
Therefore, the ability to identify real information, track it back to the source article and make your own judgement is a very important skill. This activity will help you develop that skill.

Mobile phone batteries cause fires.
News article – http://www.telegraph.co.uk/technology/2016/10/14/us-bans-samsung-galaxy-note-7-phones-from-airliners/
News article – http://www.bbc.co.uk/news/business-37674170
News article – http://fortune.com/2017/01/12/airlines-samsung-galaxy-note-7-warning/
Information - Fire fighting for lithium battery fires | DENIOS
Journal article – https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5577247/
News website – https://www.theregister.co.uk/2017/01/17/li_ion_self_extinguishing_battery/

Task
You need to produce a 1 page essay on the dangers associated with lithium batteries and how scientists are overcoming these.

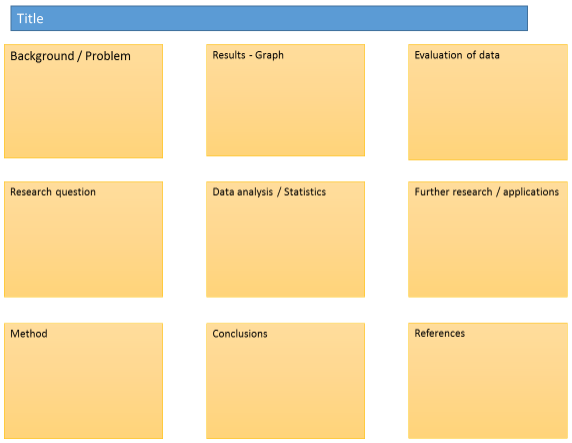
Essay section	Activity
Introduction	What is a lithium battery?
Describe	Describe how lithium batteries work and why they are a fire risk. Do all electrochemical cells pose a fire risk?
Evaluate	Evaluate the risks and benefits of lithium batteries.
Conclude & Reflect	Does the risk outweigh the benefit? Is there any way to make lithium batteries completely safe?

PiXL Independence – Level 4
Scientific Posters
A Level Chemistry – Electrode potentials and electrochemical cells

Scientific Posters - Scientists communicate research findings in three main ways. Primarily, they write journal articles much like an experiment write up. These are very concise, appraise the current literature on the problem and present findings. Scientists then share findings at conferences through talks and scientific posters. During a science degree, you would practice all three of these skills.

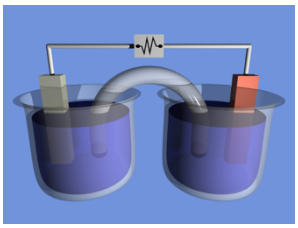
Scientific posters are a fine balance between being graphically interesting and attracting attention and sharing just the right amount of text to convey a detailed scientific message. They are more detailed than a talk and less detailed than a paper.
Use this information to help structure your poster – https://www.wikihow.com/Make-a-Scientific-Poster
More detailed guidance is available at: https://guides.nyu.edu/posters

Creating your poster
It is easiest to create a poster in PowerPoint, however you need to add custom text boxes rather than using the standard templates.



Posters need to be eye catching, but readable from a distance. If you use PowerPoint, start with a 4:3 slide (for easier printing, it can then be printed on A3) and use a 14-16 pt font. The first box could be larger to draw people in. You can use a background image, but pick a simple one that is of high quality. Select 'text box fill' and select 'change the transparency' to maintain the contrast and partially show the picture.
You can experiment with different layouts and you should include images. Avoid a chaotic layout, posters are read from top left column downwards.
Remember to include the authors and references.
Finally, look at the examples given on the University of Texas website which also offers an evaluation of each https://ugs.utexas.edu/our/poster/samples

Electrochemical cells



Background

Alessandro Volta, who published his experiments in 1799, made the voltaic pile. This was the first electrical battery that could continuously provide an electrical current to a circuit. As a result, 19th century industry became largely powered by batteries related to Volta's with a number of scientists developing his initial idea.

Source article: https://en.wikipedia.org/wiki/Voltaic_pile
Source article: http://www.electrochem.org/birth-of-electrochemistry
Source article: http://bgr.com/2017/05/09/tesla-battery-life-jeff-dahn/

Use other sources as necessary.

Task

Produce a scientific poster on the development of electrochemical cells.
Investigate how knowledge and understanding of electrochemical cells has evolved from the first voltaic battery produced by Volta.

Recall	Explain the terms oxidation and reduction in terms of electrons and oxidation number.
Describe	Describe Volta's discovery.
Explain	Explain how knowledge and understanding of electrochemical cells has evolved over time through to the modern-day lithium battery.
Discuss	Battery technology is essential for a 'greener planet'. Discuss the future of electrochemical cells.

PiXL Independence – Level 5
Video summaries
A Level Chemistry – Electrode potentials and electrochemical cells

Cornell Notes

At A level and University, you will make large amounts of notes, but those notes are only of use if you record them in a sensible way. One system for recording notes is known as the Cornell notes system. This method encourages you to select relevant information, rather than trying to write a transcript of everything said. More importantly, it forces you to spend a few minutes reviewing what you have written, which has been scientifically proven to aid learning and memory retention.
The ideal is to write everything on one page, but some students may prefer to type and others will to handwrite their notes. Whichever option you use, remember the aim is to summarise and condense the content with a focus on the objectives that you are trying to learn and understand.

There are three main sections to the Cornell notes

1. **Cue/ Objectives** – This can be done before or after the lecture. You may have been provided with the objectives or you may need to decide what they were or you may want to make the link to your learning if this is an additional task or lecture you are viewing, such as this video.
2. **Notes** – In this space you record concisely, simply the things you are LESS likely remember - **The NEW knowledge.**
3. **Summary** – The most important step that is carried out after the lecture or video. This helps to reinforce learning.

Background

The following series of videos link to your learning. The first is a summary of essential learning on electrochemistry produced by the excellent 'Crash Course'. The second discusses the importance of large-scale batteries that are able to store renewable energy.

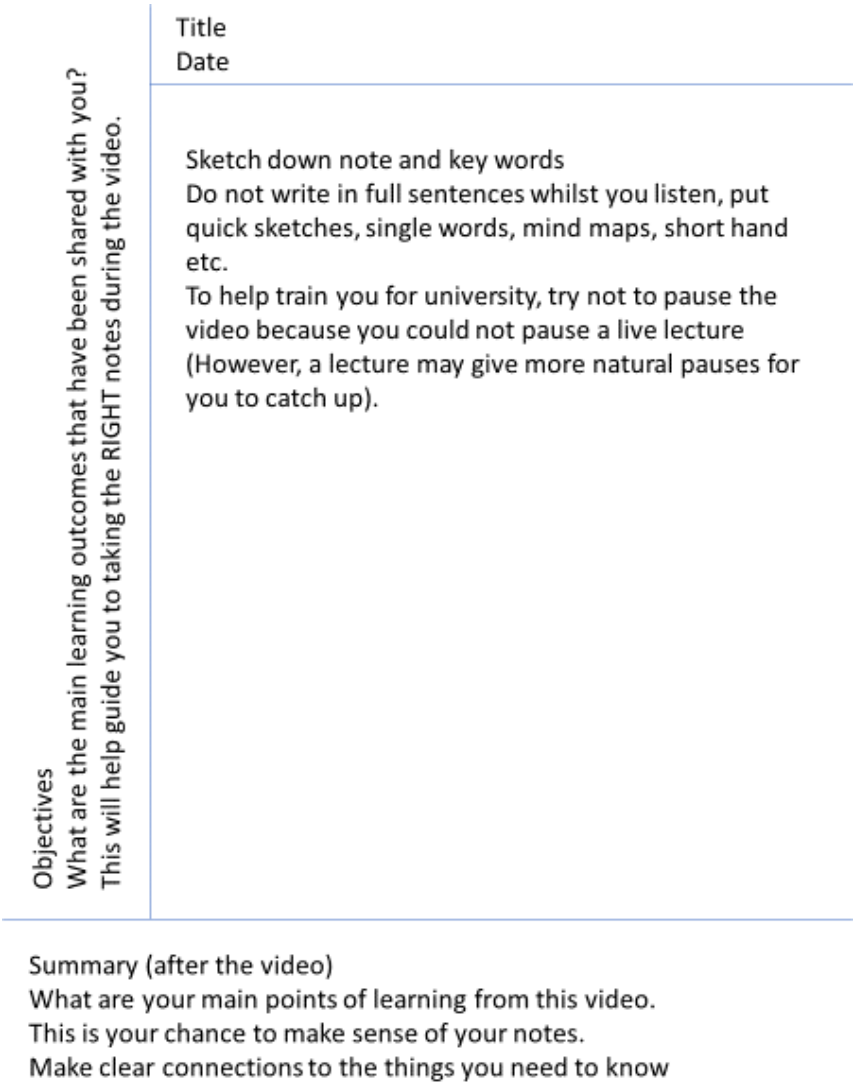
Source article:
Video 1 – Electrochemistry
CrashCourse: https://www.youtube.com/watch?v=IV4IUsholjg

Video 2 – The missing link to renewable energy
TED talk: https://www.ted.com/talks/donald_sadoway_the_missing_link_to_renewable_energy

Task:

You need to produce a set of Cornell notes for each of the videos given above.
Use the following objective to guide your note taking, this links to your learning.

1. Summarise your learning from the Crash Course video.
2. Explain the importance of batteries in the future of renewable energy.



	Title **Date**
Objectives	
Summary	

	Title **Date**
Objectives	
Summary	

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