LACHLAN ACCESS PROGRAM

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NAME & TYPE OF TASK: Practical Investigation – Redox Reaction

COURSE: Preliminary Chemistry 2021	TASK NUMBER: 2
DATE ISSUED: Term 2 Week 7, Wednesday the 3rd June 2021	DATE DUE: Term 2 Week 10, Monday 21st June 2021
TOTAL MARKS: 30	WEIGHTING: 30%
COORDINATING TEACHER: Mrs Hughes	CO-TEACHERS: Mr Kavale

Submission process to be followed:

- The task must be saved in pdf format.
- The task is to be submitted via email to westernlap@det.nsw.edu.au by 9am of the due date.
- Email heading and filename should be in the format: Your Last name, First initial, Subject and task number. For example: NyeBBiologyTask4
- Tasks are not to be emailed to the coordinating teacher or the classroom teacher.
- Make sure you ask for a read receipt and a delivery receipt for your email - these are found in the options section of your new message.
- If an extension is required, paperwork is to be submitted to your in-school access coordinator at least 7 days prior to the task due date. If you are aware that you may be away on the due date, submit it prior to the due date.

Syllabus Content:

Inquiry question: How is the reactivity of various metals predicted?

Students:

- apply the definitions of oxidation and reduction in terms of electron transfer and oxidation numbers to a range of reduction and oxidation (redox) reactions
- conduct investigations to measure and compare the reduction potential of galvanic half-cells
- construct relevant half-equations and balanced overall equations to represent a range of redox reactions
- predict the reaction of metals in solutions using the table of standard reduction potentials
- predict the spontaneity of redox reactions using the value of cell potentials

Outcomes to be assessed:

- CH11-1: develops and evaluates questions and hypotheses for scientific investigation
- CH11-2: designs and evaluates investigations in order to obtain primary and secondary data and information
- CH11-3: conducts investigations to collect valid and reliable primary and secondary data and information
- CH11-5: analyses and evaluates primary and secondary data and information

Task Description:

- Students will complete a practical investigation to create a galvanic cell and use this to measure the electrode potential and consequently rank their reduction strength.
- Students will then undertake an analyse of their data and compare calculated values to known values.

Task is shown on the next page.

Investigation: Measurement of electrode potentials and ranking the reduction strengths of their reduced forms

Background:

In this investigation, the copper electrode will be used as a reference electrode to measure the electrode potential of each of several other electrodes. This will allow us to list the electrode half-reactions in order of decreasing tendency to occur, because the higher the electrode potential, the greater the tendency for that half reaction to occur or the greater the oxidising strength of the oxidised form of the half reaction. Then we will be able to rank the reduced forms of the half reactions in order of increasing reduction strength.
Table 12.2 shows the standard electrode potentials at 25^{oC}. In this table the half reactions are all reduction half equations written as:

$$\text{Oxidised form} + ne^- \rightarrow \text{reduced form}$$

In a reduction half reaction the species on the left-hand side is the oxidant: it takes electrons from a species in another half reaction.

When comparing two reduction half reactions, the one with the larger $E^\ominus$ goes as written and the other one goes in reverse. As a consequence of this statement:

- The greater the value of $E^\ominus$, the greater the oxidizing strength of the oxidized form (left-hand side) of the half reaction
- The smaller the value of $E^\ominus$, the greater the reducing strength of the reduced form (right-hand side) of the reduction half reaction.

Aim:

To measure and compare the reduction potentials of several electrodes using the Cu, Cu2+ electrode as a reference electrode and to determine the relative strengths of the reductants involved.

Hypothesis:

Propose a suitable hypothesis.

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Materials:

- 50ml of 1.0mol L-1 solutions of:
  - $CuSO_4$
  - $MgSO_4$
  - Acidified $FeSO_4$
  - $ZnSO_4$
  - KNO_3
  - KI
- Strips of Cu, Mg and ZN metals
- 1 ungalvanised nail
- 1 graphite electrode
- 0.2g iodine solid
- 5x150ml beakers
- Waste bottles x 2
- 7cm x 7cm piece of sandpaper
- Voltmeter
- Electrical wires
- Filter paper
- Petri dish
- Labels
- Blu tack
- Forceps
- Stirring rod
- Power pack

Method:

1. Pour 50ml of $CuSO_4$, $MgSO_4$, Acidified $FeSO_4$ and $ZnSO_4$ into separate labelled beakers.
2. Clean the metals with sandpaper.
3. Stand the pieces of metal in separate beakers with their corresponding solutions so that they are partly submerged. It may be useful to use Blu Tack to hold the metals in place
4. Pour 50ml of iodide solution into another beaker, add 0.2g solid iodine to the solution, stir until dissolved then stand the graphite electrode in it.
5. Soak a piece of filter paper in the petri dish with KNO3.
6. Place the piece of filter paper so that one end is in the copper solution and the other end is in the solution of the electrode being tested.
7. Connect the metal strip (graphite electrode in the iodide, iodine half-cell) and copper strip to the voltmeter with electrical wires.
8. Record the voltage of the electrode being tested relative to the copper electrode, including its sign.
9. Connect each of the half cells (electrodes) in turn to the copper electrode, using a fresh piece of soaked filter paper for each cell, and measure the voltage.
10. Make up three cells that do not include a copper electrode and measure their voltages.

Results:

Record the voltage for each galvanic cell in a suitable table.

Analysis of Results:

1. Calculate the electrode potential of each of the electrodes you measured from:

   $$E = E_{test} - E_{Cu} = E_{test} - 0.34$$

   where E is the measured voltage of the electrode relative to the copper electrode and E_{test} is its electode potential. Enter the values in your table. (Working space included below)

2. Write the reduction half reactions associated with each of the electrodes listed.

3. List the reactions in order of decreasing tendency to occur (that is, list the one with the greatest tendency to occur first and the one with the least last).

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4. List the reductants in these half reactions in order of decreasing strength as reductants.

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5. Use the method you used to calculate electrode potentials from analysis step 1 to calculate the voltages you would expect for the cells you made in method step 10.

6. Compare these calculated values with the measured values and comment on any discrepancies.

Conclusion:

1. Compare your electrode potentials with the values in Table 12.2.

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2. Compare the voltages measured in method step 10 and those calculated in analysis step 5 with values calculated for these cells from Table 12.2.

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3. Suggest reasons for any discrepancies between your results and the data in Table 12.2.

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TABLE 12.2 Standard electrode potentials at 25°C

Oxidising strength of the oxidised form increases ↑

OXIDISED FORM + ne^-	→	REDUCED FORM	$\varepsilon^{\ominus}$(V)
$F_2 + 2e^-$	→	$2F^-$	+2.87
$H_2O_2 + 2H^+ + 2e^-$	→	$2H_2O$	+1.78
$Au^+ + e^-$	→	Au	+1.69
$MnO_4^- + 8H^+ + 5e^-$	→	$Mn^{2+} + 4H_2O$	+1.51
$PbO_2 + 4H^+ + 2e^-$	→	$Pb^{2+} + 2H_2O$	+1.46
$Cl_2 + 2e^-$	→	$2Cl^-$	+1.36
$O_3 + H_2O + 2e^-$	→	$O_2 + 2OH^-$	+1.24
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	→	$2Cr^{3+} + 7H_2O$	+1.23
$O_2 + 4H^+ + 4e^-$	→	$2H_2O$	+1.23
$MnO_2 + 4H^+ + 2e^-$	→	$Mn^{2+} + 2H_2O$	+1.22
$Pt^{2+} + 2e^-$	→	Pt	1.18
$Ag_2O + 2H^+ + 2e^-$	→	$2Ag + H_2O$	+1.17
$Br_2 + 2e^-$	→	$2Br^-$	+1.09
$NO_3^- + 4H^+ + 3e^-$	→	$NO + 2H_2O$	+0.96
$NO_3^- + 3H^+ + 2e^-$	→	$HNO_2 + H_2O$	+0.93
$2Hg^{2+} + 2e^-$	→	Hg_2^{2+}	+0.92
$Hg^{2+} + 2e^-$	→	Hg	+0.85
$NO_3^- + 2H^+ + e^-$	→	$NO_2 + H_2O$	+0.80
$Ag^+ + e^-$	→	Ag	+0.80
$Fe^{3+} + e^-$	→	Fe^{2+}	+0.77
$O_2 + 2H^+ + 2e^-$	→	H_2O_2	+0.70
$MnO_4^- + 2H_2O + 3e^-$	→	$MnO_2 + 4OH^-$	+0.60
$I_2 + 2e^-$	→	$2I^-$	+0.54
$O_2 + 2H_2O + 4e^-$	→	$4OH^-$	+0.40
$Ag_2O + H_2O + 2e^-$	→	$2Ag + 2OH^-$	+0.34
$Cu^{2+} + 2e^-$	→	Cu	+0.34
$SO_4^{2-} + 4H^+ + 2e^-$	→	$H_2SO_3 + H_2O$	+0.17
$Sn^{4+} + 2e^-$	→	Sn^{2+}	+0.15
$S + 2H^+ + 2e^-$	→	H_2S	+0.14
$S_4O_6^{2-} + 2e^-$	→	$2S_2O_3^{2-}$	+0.08
$2H^+ + 2e^-$	→	H_2	0.00
$Pb^{2+} + 2e^-$	→	Pb	−0.13
$Sn^{2+} + 2e^-$	→	Sn	−0.14
$Ni^{2+} + 2e^-$	→	Ni	−0.26
$Co^{2+} + 2e^-$	→	Co	−0.28
$PbSO_4 + 2e^-$	→	$Pb + SO_4^{2-}$	−0.36
$Cd^{2+} + 2e^-$	→	Cd	−0.40
$Fe^{2+} + 2e^-$	→	Fe	−0.45
$2CO_2 + 2H^+ + 2e^-$	→	$H_2C_2O_4$	−0.49
$Zn^{2+} + 2e^-$	→	Zn	−0.76
$2H_2O + 2e^-$	→	$H_2 + 2OH^-$	−0.83
$Al^{3+} + 3e^-$	→	Al	−1.66
$Mg^{2+} + 2e^-$	→	Mg	−2.37
$Na^+ + e^-$	→	Na	−2.71
$Ca^{2+} + 2e^-$	→	Ca	−2.87
$Ba^{2+} + 2e^-$	→	Ba	−2.91
$K^+ + e^-$	→	K	−2.93

Reducing strength of the reduced form increases ↓

Marking Criteria:

Outcomes	*Outstanding*	*High*	*Sound*	*Developing*	*Limited*
CH11-1: develops and evaluates questions and hypotheses for scientific investigation			Provides hypothesis for experiment that predicts ranking of metals by potential **(3 marks)**	Provides hypothesis that ranks most of the metals by potential **(2 marks)**	Hypothesis provided but metals not ranked **(1 mark)**
CH11-2: designs and evaluates investigations in order to obtain primary and secondary data and information			Can compare results with known data to suggest valid reasons for result discrepancies and suggests appropriate adjustments to experimental procedure **(5-6 marks)**	Compares some results with known data to suggest some reasons for result discrepancies and suggest some adjustments to experimental procedure **(3-4 marks)**	States known data and results and/or suggests reasons for result discrepancy and/or suggest some experimental adjustments **(1-2 marks)**
CH11-3: conducts investigations to collect valid and reliable primary and secondary data and information	Safely and efficiently conducts practical. Follows instructions independently **(5 marks)**	Safely completes practical. Clarifications needed on some instructions **(4 marks)**	Safety reminders needed. Clarifications on a range of instructions **(3 marks)** Accurate data collected and recorded appropriately **(4 marks)**	Safety reminders needed. Clarifications on a range of instructions **(2 marks)** Data collected (with errors) or data not adequately organised **(2-3 marks)**	Student completes task under direct supervision **(1 mark)** Student requires support to read and collect data **(1 mark)**
CH11-5: analyses and evaluates primary and secondary data and information	Completes accurate analysis of results with correct calculations, half-equations and ranking **(12 marks)**	Completes analysis of results with mostly correct calculations, half-equations and ranking **(9-11 marks)**	Completes accurate analysis of results with correct calculations, half-equations and ranking **(6-8 marks)**	Completes accurate analysis of results with correct calculations, half-equations and ranking **(3-5 marks)**	Completes accurate analysis of results with correct calculations, half-equations and ranking **(1-2 marks)**

WORD	MEANING
Account	Account for: state reasons for, report on. Give an account of: narrate a series of events or transactions
Analyse	Identify components and the relationship between them; draw out and relate implications
Apply	Use, utilise, employ in a particular situation
Appreciate	Make a judgement about the value of
Assess	Make a judgement of value, quality, outcomes, results or size
Calculate	Ascertain/determine from given facts, figures or information
Clarify	Make clear or plain
Classify	Arrange or include in classes/categories
Compare	Show how things are similar or different
Construct	Make; build; put together items or arguments
Contrast	Show how things are different or opposite
Critically (analyse/evaluate)	Add a degree or level of accuracy depth, knowledge and understanding, logic, questioning, reflection and quality to (analyse/evaluate)
Deduce	Draw conclusions
Define	State meaning and identify essential qualities
Demonstrate	Show by example
Describe	Provide characteristics and features
Design	*Do or plan (something) with a specific purpose or intention in mind*
Discuss	Identify issues and provide points for and/or against
Distinguish	Recognise or note/indicate as being distinct or different from; to note differences between
Evaluate	Make a judgement based on criteria; determine the value of
Examine	Inquire into
Explain	Relate cause and effect; make the relationships between things evident; provide why and/or how
Extract	Choose relevant and/or appropriate details
Extrapolate	Infer from what is known
Give an example	*Do exactly that and no more, but make sure it is specific to the rest of the question*
How	*In what way or manner; by what means*
Identify	Recognise and name
Interpret	Draw meaning from
Investigate	Plan, inquire into and draw conclusions about
List	*Make a set of items considered as being in the same category or having a particular order of priority*
Justify	Support an argument or conclusion
Outline	Sketch in general terms; indicate the main features of
Predict	Suggest what may happen based on available information
Propose	Put forward (for example a point of view, idea, argument, suggestion) for consideration or action
Recall	Present remembered ideas, facts or experiences
Recommend	Provide reasons in favour
Recount	Retell a series of events
Summarise	Express, concisely, the relevant details
Synthesise	Putting together various elements to make a whole
To what extent	*How much, to what degree or how many*
Translate	*Move from one place or condition to another*
What	*Asking for information specifying something (mark allocation will determine the extent of information required)*
Why	*For what reason or purpose*