CHEMISTRY

Written examination 2

Friday 11 November 2005
Reading time: 9.00 am to 9.15 am (15 minutes)
Writing time: 9.15 am to 10.45 am (1 hour 30 minutes)

QUESTION AND ANSWER BOOK

Structure of book

<table>
<thead>
<tr>
<th>Section</th>
<th>Number of questions</th>
<th>Number of questions to be answered</th>
<th>Number of marks</th>
<th>Suggested times (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>27</td>
</tr>
<tr>
<td>B</td>
<td>9</td>
<td>9</td>
<td>60</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total 80</td>
<td></td>
<td>90</td>
</tr>
</tbody>
</table>

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, an approved graphics calculator (memory cleared) and/or one scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied
- Question and answer book of 19 pages, with a detachable data sheet in the centrefold.
- Answer sheet for multiple-choice questions.

Instructions
- Detach the data sheet from the centre of this book during reading time.
- Write your **student number** in the space provided above on this page.
- Check that your **name** and **student number** as printed on your answer sheet for multiple-choice questions are correct, **and** sign your name in the space provided to verify this.
- All written responses must be in English.

At the end of the examination
- Place the answer sheet for multiple-choice questions inside the front cover of this book.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.
SECTION A – Multiple-choice questions

Instructions for Section A

Answer all questions in pencil on the answer sheet provided for multiple-choice questions. Choose the response that is correct or that best answers the question. A correct answer scores 1, an incorrect answer scores 0. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Question 1
The trisaccharide formed from the reaction of three glucose (C₆H₁₂O₆) molecules has the formula
A. C₁₈H₃₆O₁₈
B. C₁₈H₃₄O₁₇
C. C₁₈H₃₂O₁₆
D. C₁₈H₃₀O₁₅

Question 2
The reaction between a glycerol molecule and three long-chain carboxylic acid molecules is a
A. condensation reaction and the product contains a – C – O – C – group.
B. hydrolysis reaction and the product contains a – C – O – C – group.
C. condensation reaction and the product contains a – C – O – O – C – group.
D. hydrolysis reaction and the product contains a – C – O – O – C – group.

Question 3
The substances below are present in the food we eat. Which one provides the lowest amount of energy per gram for the human body?
A. tristearin (a triglyceride)
B. glycine (an amino acid)
C. cellulose (a polysaccharide)
D. glucose (a monosaccharide)
Question 4
Nitrifying and denitrifying bacteria play important roles in the nitrogen cycle. They are involved in the following reactions.

\[
\begin{align*}
\text{NH}_4^+(aq) & \xrightarrow{\text{nitrifying bacteria}} \text{NO}_3^-(aq) \quad \text{reaction 1} \\
\text{NO}_3^-(aq) & \xrightarrow{\text{denitrifying bacteria}} \text{N}_2(g) \quad \text{reaction 2}
\end{align*}
\]

Which one of the following alternatives correctly describes both of these reactions?

<table>
<thead>
<tr>
<th>Reaction 1</th>
<th>Reaction 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. nitrogen fixation</td>
<td>oxidation</td>
</tr>
<tr>
<td>B. oxidation</td>
<td>nitrogen fixation</td>
</tr>
<tr>
<td>C. nitrogen fixation</td>
<td>reduction</td>
</tr>
<tr>
<td>D. oxidation</td>
<td>reduction</td>
</tr>
</tbody>
</table>

Question 5
The reaction between solutions of hydrochloric acid and sodium hydroxide can be represented by the following equation.

\[
\text{HCl}(aq) + \text{NaOH}(aq) \rightarrow \text{NaCl}(aq) + \text{H}_2\text{O}(l) \quad \Delta H = -56 \text{ kJ mol}^{-1}
\]

60.0 mL of 2.0 M HCl, at 21°C, is mixed with 40.0 mL of 2.0 M NaOH, also at 21°C, in a well-insulated calorimeter. The calibration factor for the calorimeter and contents is 420 J K\(^{-1}\).

The final temperature, in °C, of the resultant solution in the calorimeter would be closest to

<table>
<thead>
<tr>
<th>Option</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>11</td>
</tr>
<tr>
<td>B.</td>
<td>32</td>
</tr>
<tr>
<td>C.</td>
<td>37</td>
</tr>
<tr>
<td>D.</td>
<td>52</td>
</tr>
</tbody>
</table>

Question 6
Which one of the following would be predicted to spontaneously oxidise aqueous iodide ions but not aqueous chloride ions?

<table>
<thead>
<tr>
<th>Option</th>
<th>Ionic Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Au(^+)(aq)</td>
</tr>
<tr>
<td>B.</td>
<td>Sn(^2+)(aq)</td>
</tr>
<tr>
<td>C.</td>
<td>Fe(^2+)(aq)</td>
</tr>
<tr>
<td>D.</td>
<td>Br(_2)(aq)</td>
</tr>
</tbody>
</table>

Question 7
The rechargeable nickel-cadmium cell is used to power small appliances such as portable computers. When the cell is being used, the electrode reactions are represented by the following equations.

\[
\begin{align*}
\text{NiO}_2(s) + 2\text{H}_2\text{O}(l) + 2e^- & \rightarrow \text{Ni(OH)}_2(s) + 2\text{OH}^- (aq) \\
\text{Cd}(s) + 2\text{OH}^- (aq) & \rightarrow \text{Cd(OH)}_2(s) + 2e^- 
\end{align*}
\]

Which of the following occurs during the \textbf{recharging} of the nickel-cadmium cell?

I  cadmium is deposited on the negative electrode
II  the pH of the electrolyte increases
III the direction of electron flow in the external circuit is from the anode to the cathode

A. I only  
B. I and II only  
C. II and III only  
D. I and III only

Question 8
A galvanic cell consists of one half cell that is made up of an inert graphite electrode in a solution containing 1.0 M \text{Fe}^{2+}(aq) and 1.0 M \text{Fe}^{3+}(aq) at 25°C.

Which one of the following could be used as the second half cell so that the polarity of the electrode in this second half cell is positive?

A. a lead electrode in a solution of 1.0 M \text{Pb}^{2+}(aq)  
B. a silver electrode in a solution of 1.0 M \text{Ag}^{+}(aq)  
C. an iron electrode in a solution of 1.0 M \text{Fe}^{2+}(aq)  
D. an inert graphite electrode in a solution of 1.0 M \text{Br}^{-}(aq)

Questions 9 to 11 refer to the following information.

A copper disc is to be silver-plated in an electrolytic cell. The disc forms one electrode and a silver rod the other electrode. The electrolyte provides a source of \text{Ag}^{+}(aq).

Question 9
The disc to be plated is connected to the

A. positive terminal of a battery so that oxidation occurs at the disc.  
B. positive terminal of a battery so that reduction occurs at the disc.  
C. negative terminal of a battery so that oxidation occurs at the disc.  
D. negative terminal of a battery so that reduction occurs at the disc.

Question 10
The mass of silver to be deposited is 0.150 g.

If the current is held steady at 1.50 amps, the time, in seconds, that it takes to complete the plating is closest to

A. 90  
B. 180  
C. 200  
D. 360
Question 11
An identical disc is to be gold-plated with a solution containing \( \text{Au}^{3+}(aq) \) as the electrolyte using a current of 1.50 amps.
The ratio of the time that is needed to plate the disc with 0.150 g of gold to the time needed to plate the disc with 0.150 g of silver is closest to
A. 1 to 3
B. 1 to 1.6
C. 1.6 to 1
D. 3 to 1

Question 12
An electrolytic cell is used commercially to extract aluminium from its ore. The anode and cathode of this electrolytic cell are composed of

<table>
<thead>
<tr>
<th>anode</th>
<th>cathode</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>carbon</td>
</tr>
<tr>
<td>B.</td>
<td>carbon</td>
</tr>
<tr>
<td>C.</td>
<td>iron</td>
</tr>
<tr>
<td>D.</td>
<td>iron</td>
</tr>
</tbody>
</table>

Question 13
In which one of the following processes will the \( \Delta H \) have the opposite sign to that of the other three?
A. \( \text{I}_2(s) \rightarrow \text{I}_2(g) \)
B. \( \text{Na}^+(g) + e^- (g) \rightarrow \text{Na}(g) \)
C. \( \text{CO}_2(g) \rightarrow \text{C}(s) + \text{O}_2(g) \)
D. \( 2\text{NaCl}(l) \rightarrow 2\text{Na}(l) + \text{Cl}_2(g) \)

Question 14
Element X has an atomic radius that is smaller than that of sulfur. In chemical reactions, element X commonly forms an ion that has the same electron configuration as the \( \text{Sc}^{3+} \) ion.
Element X could be
A. oxygen.
B. chlorine.
C. argon.
D. potassium.

Question 15
In which one of the following sets of chromium-containing compounds do the chromium atoms all have the same oxidation number?
A. \( \text{Cr}_2\text{O}_3 \quad \text{K}_2\text{Cr}_2\text{O}_7 \quad \text{Na}_2\text{CrO}_4 \)
B. \( \text{CrCl}_2 \quad \text{Cr}_2\text{O}_3 \quad \text{K}_2\text{Cr}_2\text{O}_7 \)
C. \( \text{Cr}_2\text{O}_3 \quad \text{CrCl}_3 \quad \text{Cr(NO}_3)_3 \)
D. \( \text{Na}_2\text{CrO}_4 \quad \text{CrO}_3 \quad \text{Cr(NO}_3)_3 \)
**Question 16**
Sodium and chlorine are both in Period 3.
You would expect sodium to have
A. the lower ionisation energy and the lower electronegativity.
B. the higher ionisation energy and the lower electronegativity.
C. the lower ionisation energy and the higher electronegativity.
D. the higher ionisation energy and the higher electronegativity.

**Question 17**
The noble gases (helium to radon) have an outer shell electron configuration of
A. s²
B. s²p⁶
C. either s² or s²p⁶
D. either s²p⁶ or s²p⁶d¹⁰

**Question 18**
Potassium has a radioactive isotope, ⁴⁰K. One of the ways this isotope disintegrates leads to the emission of a beta particle (an electron) by the ⁴⁰K nucleus.
The new nucleus produced by this disintegration is
A. ⁴⁰K⁺
B. ⁴¹K
C. ⁴⁰Ar
D. ⁴⁰Ca

**Question 19**
Consider the following three compounds which contain complex ions that involve iron
I  [Fe(NH₃)₆]Cl₃
II  K₃[FeCl₆]
III  K₄[FeCl₆]
The oxidation state of the iron in each of these compounds is

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>+3</td>
<td>−3</td>
<td>−2</td>
</tr>
<tr>
<td>B</td>
<td>+3</td>
<td>+3</td>
<td>+2</td>
</tr>
<tr>
<td>C</td>
<td>+6</td>
<td>+6</td>
<td>+6</td>
</tr>
<tr>
<td>D</td>
<td>+3</td>
<td>−3</td>
<td>−4</td>
</tr>
</tbody>
</table>

**Question 20**
Which one of the following is least likely to act as a ligand with Fe³⁺ ions?
A. F⁻
B. CN⁻
C. H₂O
D. NH₄⁺

END OF SECTION A
SECTION B – Short-answer questions

Instructions for Section B

Answer all questions in the spaces provided.
To obtain full marks for your responses you should
• give simplified answers with an appropriate number of significant figures to all numerical questions; unsimplified answers will not be given full marks.
• show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.
• make sure chemical equations are balanced and that the formulas for individual substances include an indication of state; for example, H₂(g); NaCl(s)

Question 1

From the following list of elements

<table>
<thead>
<tr>
<th>Li</th>
<th>Be</th>
<th>B</th>
<th>C</th>
<th>N</th>
<th>O</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na</td>
<td>Mg</td>
<td>Al</td>
<td>Si</td>
<td>P</td>
<td>S</td>
<td>Cl</td>
</tr>
</tbody>
</table>

give the symbol or name for

a. the most electronegative element ________________

b. the element that commonly forms an ion which has an electron configuration of 1s²2s²2p⁶ and a –2 charge ________________

c. an element that forms an amphoteric oxide ________________

d. an element X that forms oxides with the formula XO and XO₂ ________________

e. an element that is found in proteins but not in carbohydrates ________________

Total 5 marks
**Question 2**
Magnesium has three naturally occurring isotopes. Their relative abundances and masses are given in the table below.

<table>
<thead>
<tr>
<th></th>
<th>Percentage abundance</th>
<th>Relative isotopic mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{24}\text{Mg}$</td>
<td>78.99</td>
<td>23.985</td>
</tr>
<tr>
<td>$^{25}\text{Mg}$</td>
<td>10.00</td>
<td>24.986</td>
</tr>
<tr>
<td>$^{26}\text{Mg}$</td>
<td>11.01</td>
<td>25.983</td>
</tr>
</tbody>
</table>

**a.** The abundances and relative isotopic masses have been determined experimentally. What instrument is commonly used to obtain this information?

1 mark

**b.** Using the information above, show how the relative atomic mass of magnesium can be determined. Calculate your answer to an appropriate number of significant figures.

3 marks
c. Calcium is in the same group of the periodic table as magnesium.
   i. Explain why Mendeleev would have placed these two elements in the same vertical group.

   ii. The electronegativity of magnesium (1.31) is greater than that of calcium (1.00). Give a brief explanation for this difference.

   iii. Write the electron configuration, in terms of shells and subshells, for the calcium atom.

   iv. Write the electron configuration, in terms of shells and subshells, for the Ca$^{2+}$ ion.

   v. The radius of the calcium atom is $1.97 \times 10^{-10}$ m.
The radius of the Ca$^{2+}$ ion is $9.9 \times 10^{-11}$ m.
Explain why the calcium atom is significantly larger than the Ca$^{2+}$ ion.

1 + 2 + 1 + 1 + 1 = 6 marks
Total 10 marks
Question 3

a. Coke, which is essentially pure carbon, is widely used as a fuel. Its complete combustion can be represented by the following equation.

\[ C(s) + O_2(g) \rightarrow CO_2(g) \quad \Delta H = -393 \text{ kJ mol}^{-1} \]

However, under certain conditions, the combustion is incomplete and the following reaction also occurs.

\[ 2C(s) + O_2(g) \rightarrow 2CO(g) \quad \Delta H = -232 \text{ kJ mol}^{-1} \]

Calculate the energy, in kJ, released when 2.00 tonne (1 tonne = 10^6 gram) of coke is reacted with oxygen if 80% of the coke is oxidised to carbon dioxide and the remaining 20% is oxidised to carbon monoxide.


4 marks

b. Carbon is also a reactant in nuclear fusion reactions in some stars. One such reaction can be represented by the following equation.

\[ ^{12}_6C + ^4_2He \rightarrow ^{16}_8O + \text{energy} \]

For a given amount of carbon, significantly more energy is released in nuclear fusion reactions than in chemical reactions.

i. What is the source of the energy released in this nuclear fusion reaction?

ii. Why is nuclear fusion not currently used as an energy source in our society?

1 + 1 = 2 marks
c. Consider the following list of forms of energy.

chemical   electrical   mechanical   nuclear   solar   thermal

In a coal-fired power station, the energy released from the combustion of coal undergoes several energy conversions before electricity is generated.

i. Using the forms of energy listed above, complete the energy conversions that occur in the following stages of a coal-fired power station. (The same form of energy may be used more than once.)

Coal is oxidised to generate steam ________________ energy to ________________ energy

Steam is used to drive a turbine ________________ energy to ________________ energy

The turbine drives a generator ________________ energy to ________________ energy

ii. The amount of electrical energy obtained in a coal-fired power station is generally less than half of the available energy in the coal. What happens to the rest of the energy released when the coal is burnt?

__________________________________________________________________________

__________________________________________________________________________

3 + 1 = 4 marks
Total 10 marks
Question 4

a. Two common α amino acids (2-amino acids) are cysteine and serine. Their structural formulas are given below.

i. What chemical feature must an amino acid have in order to be classified as an α amino acid?

ii. Cysteine and serine can combine together to form two different dipeptides. Draw the structural formulas of these two dipeptides.

\[ \text{cysteine} \]
\[ \text{serine} \]

\[ \text{SH} \quad \text{OH} \]
\[ \text{CH}_2 \quad \text{CH}_2 \]
\[ \text{H} \quad \text{H} \]
\[ \text{N} - \text{C} - \text{C} = \text{O} \quad \text{H} - \text{N} - \text{C} - \text{C} = \text{O} \]

\[ \text{O} - \text{H} \quad \text{O} - \text{H} \]

1 + 2 = 3 marks

SECTION B – Question 4 – continued
b. Enzymes, which are composed mostly of protein, catalyse many chemical reactions. The structure of a portion of an enzyme, with some of its constituent atoms shown, is represented below.

![Enzyme Structure Diagram]

i. Name the type of chemical bond present in the parts labelled.

A ________________________________

B ________________________________

C ________________________________

ii. Why is the tertiary structure of an enzyme essential to its function?

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

3 + 1 = 4 marks
Total 7 marks
**Question 5**

Sucrose is a disaccharide. Bees use an invertase enzyme to convert sucrose to an equimolar mixture of glucose and fructose. The structural formula of sucrose is given below and one of the functional groups in the molecule has been circled.

![Structural formula of sucrose](image)

a. i. Give the name of the functional group circled in the structural formula of sucrose.

ii. To which of the major food groups does sucrose belong?

iii. Given that glucose has a six-membered ring structure, draw the structural formula of glucose.

---

b. What simple molecule is the other reactant in the conversion of sucrose to glucose and fructose?

---

3 marks

---

1 mark
c. The invertase enzyme can be isolated and used in the laboratory to form glucose and fructose from sucrose. In a particular set of experiments, equivalent amounts of the enzyme were mixed with three sucrose solutions of equal concentrations. One of the solutions was kept at 5°C throughout the experiment, one at 35°C and the last at 95°C.

The following gives the percentage yield of glucose after 30 minutes.

<table>
<thead>
<tr>
<th>Temperature at which the experiment was carried out</th>
<th>Percentage yield of glucose</th>
</tr>
</thead>
<tbody>
<tr>
<td>5°C</td>
<td>10</td>
</tr>
<tr>
<td>35°C</td>
<td>95</td>
</tr>
<tr>
<td>95°C</td>
<td>2</td>
</tr>
</tbody>
</table>

Explain why the percentage yield is higher at 35°C than at

i. 5°C

ii. 95°C

2 marks

Total 6 marks
Question 6
Give concise explanations for each of the following.

a. Food chemists quote the energy content of food in kJ g\(^{-1}\), rather than kJ mol\(^{-1}\).

b. Hydrogen gas is bubbled through a solution of 1.0 M Fe\(^{3+}\)(aq) ions. On the basis of the electrochemical series, a redox reaction is predicted to occur. In practice, no reaction occurs at room temperature.

c. The oxidation state of iron, in its compounds, is normally either +2 or +3, whereas that of calcium, in its compounds, is +2 only.

Total 4 marks
**Question 7**

A mineral ore contains a mixture of compounds of lead and calcium, in approximately equal proportions. A chemist extracts the metal ions by roasting the ore in air and treating the product with acid. The solution that contains the Pb\(^{2+}\)(aq) and Ca\(^{2+}\)(aq) is then placed in an electrolytic cell as shown in the diagram below.

![Diagram of electrolytic cell](image)

a. Label the anode and cathode of the cell.  
   1 mark

b. When the current begins to flow in the cell, write equations for the half reaction that is likely to occur at
   the
   • positive electrode
   • negative electrode
   2 marks

c. After some time has elapsed, a new half reaction occurs at one of the electrodes. Write the equation for
   this half reaction.
   1 mark

d. If the chemist had used copper electrodes instead of platinum electrodes, how would this have affected
   the half reaction at the anode?
   1 mark

Total 5 marks
Question 8

One type of ‘breathalyser’ instrument used by police for the measurement of the concentration of alcohol in a driver’s breath is a fuel cell. An acidic electrolyte is used. Ethanol is oxidised to ethanoic acid at one electrode and oxygen from the air is converted to water at the other.

The overall equation for this reaction is

\[ \text{C}_2\text{H}_5\text{OH}(aq) + \text{O}_2(g) \rightarrow \text{CH}_3\text{COOH}(aq) + \text{H}_2\text{O}(l) \]

a. Write the equation for the half reaction at the anode.

b. A motorist who has consumed alcohol blows into the fuel cell. If the breath entering the cell provides alcohol at the rate of \(3.0 \times 10^{-5}\) g per second, calculate the maximum current, in amps, that the cell would produce.

c. The nature of the electrodes in the cell is essential to the effective operation of the breathalyser. State two important functions that the electrodes must perform.

Function 1

Function 2

Total 7 marks
Question 9
Give balanced equations for the following reactions.

a. The complete oxidation of glucose (C₆H₁₂O₆) in plant and animal cells.

b. The formation of helium by nuclear reaction in the sun.

c. The reaction between ammonia and sulfuric acid to form ammonium sulfate fertiliser.

d. The reaction of an oxide of sulfur with aqueous sodium hydroxide.

Total 6 marks
CHEMISTRY

Written examination 2

DATA SHEET

Directions to students

Detach this data sheet during reading time.

This data sheet is provided for your reference.
Physical constants

\[ F = 96\,500 \text{ C mol}^{-1} \]

\[ R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1} \]

1 atm = 101 325 Pa = 760 mmHg

0°C = 273 K

Molar volume at STP = 22.4 L mol\(^{-1}\)

Avogadro constant = \(6.02 \times 10^{23} \) mol\(^{-1}\)

The electrochemical series

\[ E^\circ \text{ in volt} \]

\[ F_2(g) + 2e^- \rightarrow 2F^-(aq) \quad +2.87 \]
\[ H_2O_2(aq) + 2H^+(aq) + 2e^- \rightarrow 2H_2O(l) \quad +1.77 \]
\[ Au^+(aq) + e^- \rightarrow Au(s) \quad +1.68 \]
\[ Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq) \quad +1.36 \]
\[ O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l) \quad +1.23 \]
\[ Br_2(l) + 2e^- \rightarrow 2Br^-(aq) \quad +1.09 \]
\[ Ag^+(aq) + e^- \rightarrow Ag(s) \quad +0.80 \]
\[ Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq) \quad +0.77 \]
\[ I_2(s) + 2e^- \rightarrow 2I^-(aq) \quad +0.54 \]
\[ O_3(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq) \quad +0.40 \]
\[ Cu^{2+}(aq) + 2e^- \rightarrow Cu(s) \quad +0.34 \]
\[ S(s) + 2H^+(aq) + 2e^- \rightarrow H_2S(g) \quad +0.14 \]
\[ 2H^+(aq) + 2e^- \rightarrow H_2(g) \quad 0.00 \]
\[ Pb^{2+}(aq) + 2e^- \rightarrow Pb(s) \quad -0.13 \]
\[ Sn^{2+}(aq) + 2e^- \rightarrow Sn(s) \quad -0.14 \]
\[ Ni^{2+}(aq) + 2e^- \rightarrow Ni(s) \quad -0.23 \]
\[ Co^{2+}(aq) + 2e^- \rightarrow Co(s) \quad -0.28 \]
\[ Fe^{3+}(aq) + 2e^- \rightarrow Fe(s) \quad -0.44 \]
\[ Zn^{2+}(aq) + 2e^- \rightarrow Zn(s) \quad -0.76 \]
\[ 2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq) \quad -0.83 \]
\[ Mn^{2+}(aq) + 2e^- \rightarrow Mn(s) \quad -1.03 \]
\[ Al^{3+}(aq) + 3e^- \rightarrow Al(s) \quad -1.67 \]
\[ Mg^{2+}(aq) + 2e^- \rightarrow Mg(s) \quad -2.34 \]
\[ Na^+(aq) + e^- \rightarrow Na(s) \quad -2.71 \]
\[ Ca^{2+}(aq) + 2e^- \rightarrow Ca(s) \quad -2.87 \]
\[ K^+(aq) + e^- \rightarrow K(s) \quad -2.93 \]
\[ Li^+(aq) + e^- \rightarrow Li(s) \quad -3.02 \]
### Periodic table of the elements

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H</td>
<td>He</td>
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