B1-B16 · Whole-unit cumulative U3

Worked solutions | Items 1-2

Scope: see the title; not a full diploma examination. Matching, ordering, ranking and selection tasks provide supplementary skill practice.

Use the givens and conditions in each prompt. Enter the requested count, coefficient, oxidation number or potential with the stated unit and precision.

U3-01 · Numerical response

Oxygen is −2 in NO_3^-. What is the oxidation number of the central atom, as a whole number (do not enter the sign)?

1. The sum of the oxidation numbers equals the ion charge, so the central atom takes the value that makes the total match.

2. For NO_3^- the central atom is +5. Enter 5.

U3-02 · Multiple choice

In the cell reaction between Mg(s) and Cu ions, Mg is oxidized. Which particle is the reducing agent?

A. Mg

B. Mg^{2+}

C. Cu^{2+}

D. Cu

1. The reducing agent is the particle that is oxidized, because it gives up the electrons.

2. Mg loses electrons, so the metal Mg is the reducing agent. Its ion and the other metal are not.

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Worked solutions | Items 3-4

U3-03 · Numerical response

Given $NO_3^- + 4H^+ + 3e^- \rightarrow NO + 2H_2O$. How many electrons are gained for each NO_3^-? Enter an integer.

1. Read the number of electrons on the left side of the half-reaction.

2. The half-reaction shows $3e^-$ for each NO_3^-.

U3-04 · Numerical response

In an acidic titration, 25.00 mL of $Fe^{2+}(aq)$ needs 15.20 mL of 0.0250 mol/L MnO_4^-. The ratio is 5 Fe^{2+} to 1 MnO_4^-. What is $[Fe^{2+}]$, in mol/L to four decimal places?

1. $n(MnO_4^-) = 0.01520\ L \times 0.0250\ mol/L$. Multiply by 5 to get $n(Fe^{2+})$.

2. Divide by 0.02500 L: $[Fe^{2+}] = 0.0760\ mol/L$.

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Worked solutions | Items 5-6

U3-05 · Numerical response

Use Ecathode − Eanode. Mg: -2.37 V. Cu: +0.34 V (data booklet). What is E°cell for the cell made from these two metals, in volts to two decimal places?

1. The metal with the lower value, Mg, is the anode.

2. E°cell = +0.34 − (-2.37) = +2.71 V.

U3-06 · Multiple choice

In a cell made from Mg (-2.37 V) and Cu (+0.34 V), which strip is the anode?

A. Mg
B. Cu
C. Both strips
D. Neither strip

1. The anode is where oxidation happens, and the lower reduction value is oxidized.

2. Mg has the lower value, so it is the anode.

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Worked solutions | Items 7-8

U3-07 · Multiple choice

For the reaction Cu(s) + Mg^{2+}(aq) written as the cell reaction, E°cell = -2.71 V. Which statement is correct?

A. The reaction is spontaneous and runs in a voltaic cell
B. The reaction is not spontaneous, so it needs a power supply (electrolytic cell)
C. The cell has no voltage
D. The reaction runs faster with a salt bridge

1. A negative E°cell means the reaction as written is not spontaneous.

2. It can happen only if a power supply forces it, so the cell is electrolytic. A salt bridge does not change the sign.

U3-08 · Multiple choice

An object is electroplated with Zn from a solution of Zn ions. At which electrode is the object and how is it connected?

A. The anode, connected to the positive terminal
B. The anode, connected to the negative terminal
C. The cathode, connected to the negative terminal
D. The cathode, connected to the positive terminal

1. Plating is reduction, and reduction happens at the cathode.

2. In an electrolytic cell the cathode is connected to the negative terminal of the power supply.

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Worked solutions | Items 9-10

U3-09 · Multiple choice

$AgNO_3(aq)$ is electrolyzed with inert electrodes. Use the booklet values (water is reduced at −0.83 V). Which product forms at the cathode?

A. $H_2(g)$
B. $O_2(g)$
C. $NO_2(g)$
D. Ag(s)

1. Reduction happens at the cathode. The couple with the higher reduction value is reduced.

2. Compare the metal ion with water at −0.83 V. The correct product is Ag(s).

U3-10 · Numerical response

A current of 4.00 A runs for 25.0 min. What charge passes, in coulombs? Enter an integer.

1. Convert the time: 25.0 min × 60 = 1500 s.

2. $q = It = 4.00 \times 1500 = 6000$ C.

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Worked solutions | Items 11-12

U3-11 · Numerical response

The charge 6000 C deposits Zn from $Zn^{2+}(aq)$. M(Zn) = 65.41 g/mol; F = 9.65×10^4 C/mol e^-. What mass is deposited, in grams to two decimal places?

1. $n(e^-) = 6000 \div (9.65 \times 10^4)$. The ratio is 2 mol e^- per mol Zn.

2. $m = n(e^-) \div 2 \times 65.41 = 2.03$ g.

U3-12 · Numerical response

What time is needed to deposit 1.20 g of Zn with a constant current of 3.00 A? M(Zn) = 65.41 g/mol; 2 mol e^- per mol; F = 9.65×10^4 C/mol e^-. Answer in minutes to two decimal places.

1. n(Zn) = 1.20 ÷ 65.41. Multiply by 2 for the moles of electrons, then by F for the charge.

2. Divide the charge by 3.00 A to get seconds, then divide by 60: t = 19.67 min.

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Worked solutions | Items 13-14

U3-13 · Multiple choice

Fe^{2+}/Fe is −0.45 V. Which metal can be attached to an iron pipe as a sacrificial anode (use the booklet reduction table)?

A. Cu
B. Ag
C. Al
D. Pb

1. A sacrificial anode must have a lower reduction value than iron, so it is oxidized instead.

2. Al has a value below −0.45 V. The others have higher values.

U3-14 · Numerical response

A device needs at least 9.0 V. Each cell gives 2.05 V and cells in a row add their voltages. How many cells are needed? Enter an integer.

1. Divide: 9.0 ÷ 2.05 = 4.39. A part of a cell cannot be used.

2. Round up to the next whole number, which is 5 cells.

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Worked solutions | Items 15-16

U3-15 · Multiple choice

A student compares the predicted and the measured voltage of a cell. Which statement is correct?

A. A voltmeter reading is a prediction
B. A value taken from the reduction table is a prediction
C. A colour change is a prediction
D. A mass change is a prediction

1. A prediction comes from the table. An observation comes from the measuring.

2. The meter reading, the colour and the mass change are observations. Only the table value is a prediction.

U3-16 · Matching

Match each problem to its method.

Items to match:

1. Voltage of a cell
2. Mass deposited from current and time
3. Concentration from a volume of MnO_4^-
4. Protect a pipe

Targets:

A. Redox titration
B. Sacrificial anode
C. Reduction table
D. Faraday’s law

1. Voltage uses the reduction table, mass from current and time uses Faraday’s law, and concentration uses a titration.

2. Protection of a pipe uses a sacrificial anode.