B1-B4 · Cumulative B

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.

CB-01 · Numerical response

A neutral Al atom has 13 protons and 13 electrons. It loses 3 electrons and becomes an ion. How many electrons does the ion have? Enter a whole number.

1. The protons do not change. The number of electrons is 13 - 3 = 10.

2. The charge of the ion is +3. The question asks for the number of electrons, not the charge.

CB-02 · Numerical response

Find sulfur’s oxidation number in SO_3^{2-}. Enter a signed integer.

1. Each O is -2, so 3 oxygens give -6. The charge of the whole ion is -2.

2. x + (-6) = -2, giving x = +4. Check: 4 - 6 = -2.

B1-B4 · Cumulative B

Worked solutions | Items 3-4

CB-03 · Numerical response

Use these reductions from the Alberta Chemistry 30 Data Booklet, Standard Electrode Potentials: $Ag^{+} + e^{-} \rightarrow Ag$, +0.80 V; $Cu^{2+} + 2e^{-} \rightarrow Cu$, +0.34 V; $Zn^{2+} + 2e^{-} \rightarrow Zn$, -0.76 V. Use standard table conditions (25 °C, 1.0 mol/L solutions; pure solids). For Zn metal with Cu^{2+} as the proposed oxidizing agent, calculate E°. Enter volts to two decimal places.

1. The ion is the oxidizing agent. Its table value is +0.34 V. The table value for the metal's row is -0.76 V.

2. E° = +0.34 - (-0.76) = +1.10 V. The positive sign means the stated direction is spontaneous under standard conditions.

CB-04 · Numerical response

One half-reaction gives off 3 electrons. The other takes in 1 electrons. What is the lowest number of electrons that both can be multiplied up to before you add them? Enter a whole number.

1. The lowest number that 3 and 1 both go into is 3. Multiply the first half by 1 and the second half by 3.

2. Multiply every part of a half-reaction, not only the electrons. If you change only the electrons, the charge no longer balances.

B1-B4 · Cumulative B

Worked solutions | Items 5-6

CB-05 · Multiple choice

Given $Mg + Cu^{2+} \rightarrow Mg^{2+} + Cu$, which reactant is the reducing agent?

A. The oxidation product
B. The reduction product
C. Mg
D. Cu^{2+}

1. Mg loses electrons. Those electrons reduce Cu^{2+}. So Mg is the reducing agent.

2. An agent is always a reactant. It is never a product.

CB-06 · Numerical response

Find the oxidation number of H in CaH_2. Enter a signed integer.

1. Ca is +2, so +2 + 2x = 0. H is -1 in this metal hydride.

2. Use the exception that fits the formula. The sum rule still holds for the whole formula.

B1-B4 · Cumulative B

Worked solutions | Items 7-8

CB-07 · Numerical response

In acidic solution, balance $Cr_2O_7^{2-} \rightarrow 2Cr^{3+}$. How many H_2O are needed to balance the oxygen? Enter a whole number.

1. The reactant has 7 oxygen atoms and the product has none. Add $7H_2O$ to the right.

2. The water brings 14 hydrogen atoms. So add $14H^+$ to the left before you balance the charge.

CB-08 · Ordering / ranking

Tests show that Zn reduces Cu^{2+} and that Cu reduces Ag^+. Put the metals in order from the strongest to the weakest reducing agent.

Strongest to weakest

1. Ag
2. Zn
3. Cu

1. The tests show Zn > Cu and Cu > Ag. So the order is Zn, Cu, Ag.

2. This is the order of the metals as reducing agents. Their ions, as oxidizing agents, are in the reverse order.

B1-B4 · Cumulative B

Worked solutions | Items 9-10

CB-09 · Multiple choice

An ion made of one atom changes from a charge of +2 to +1. Which statement is correct?

A. It lost an electron, so it was oxidized
B. It gained an electron, so it was reduced
C. It gained an electron, so it was oxidized
D. It is not redox, because both charges are positive

1. The charge goes down by one, so the ion gained one electron. This is reduction.

2. The ion is still positive, but it gained an electron. Gaining electrons is reduction.

CB-10 · Written response

C_2H_6 burns in O_2 and forms CO_2 and H_2O. Oxygen in O_2 changes from 0 to -2. Name the oxidizing agent and explain why.

1. O_2 is the oxidizing agent. Its oxidation number goes down from 0 to -2, so it is reduced.

2. C_2H_6 is the reducing agent. Name the whole reactant, O_2, not an oxygen atom in a product.

B1-B4 · Cumulative B

Worked solutions | Items 11-12

CB-11 · Numerical response

In acidic solution, the atoms are balanced in $Cr_2O_7^{2-} + 14H^+ \rightarrow 2Cr^{3+} + 7H_2O$. How many electrons must be added on the left? Enter a whole number.

1. Before the electrons, the charge on the left is -2 + 14 = +12. On the right it is 2 × (+3) = +6.

2. Add 6 electrons to bring the left down to +6. The two sides must be equal. They do not have to be zero.

CB-12 · Multiple choice

A simulation gives the same coating or no-coating result four times. Which conclusion follows?

A. A real measurement would have no error
B. Four separate real measurements were made
C. The simulation gives the same result each time
D. All effects of a dirty metal surface were measured

1. The repeated result shows the simulation follows fixed rules. C is correct.

2. It gives no real data about real metal strips, solutions or timing.

B1-B4 · Cumulative B

Worked solutions | Items 13-14

CB-13 · Written response

Given $NaCl(s) \rightarrow Na^{+}(aq) + Cl^{-}(aq)$. A student says dissolving is redox because the equation shows ions. Explain the mistake. Use what is in the solid.

1. The solid already contains Na^{+} and Cl^{-}. They only move apart in the water. No particle loses or gains electrons.

2. Charges in an equation do not prove that electrons moved. Dissolving the solid is not redox.

CB-14 · Numerical response

In a reaction, 3 carbon atom(s) change from an average oxidation number of -8/3 to +4. How many electrons are lost in total? Enter a whole number.

1. Total lost = number of atoms × increase for each atom: $3 \times (4 - (-8/3)) = 20$.

2. If the average is a fraction, keep it as a fraction until the end. The starting average here is -8/3.

B1-B4 · Cumulative B

Worked solutions | Items 15-16

CB-15 · Select all that apply

Given this half-reaction in basic solution: $OCl^- + H_2O + 2e^- \rightarrow Cl^- + 2OH^-$. Select every correct statement.

A. The Cl, O and H atoms balance

B. The charge is -3 on each side

C. Because OH^- is there, the charge does not have to balance

D. Electrons on the left mean it is a reduction

1. A, B and D are correct. Atom counts are Cl 1, O 2 and H 2. Charge is -1 - 2 = -3 on the left and -1 - 2 = -3 on the right.

2. Atoms and charge must balance in basic solution too.

CB-16 · Select all that apply

An investigation compares different pairs of a metal and an ion. Select every variable that should be kept the same for a fair test.

A. Temperature

B. Ion concentration

C. Exposed metal surface area

D. Which pair is being tested

1. Keep A, B and C the same. Keep the time and the volume the same too, if you can.

2. D is the one thing you change on purpose. If the concentration or surface area also changed, you could not tell what caused the result.

B1-B4 · Cumulative B

Worked solutions | Items 17-18

CB-17 · Written response

One Zn atom becomes Zn^{2+}. 1 Cu^{2+} ion(s) become neutral metal. Draw or describe the arrow that shows the electrons moving. Label the number of electrons, the oxidation and the reduction.

1. Draw an arrow from Zn to Cu^{2+}, with 2 electrons on it. Write “loses electrons, oxidized” at Zn. Write “gains electrons, reduced” at Cu^{2+}.

2. The arrow shows electrons moving, not atoms. The electrons that leave one end arrive at the other.

CB-18 · Multiple choice

A student sets the sum of the oxidation numbers in SO_3^{2-} equal to zero. What should the student change?

A. Change every oxygen to zero
B. Set the sum equal to -2, the charge of the ion
C. Change subscripts until the sum works
D. Treat the ion as an element by itself

1. B is correct. The numbers must add up to the charge of the ion, -2. The oxygen values and the atom counts stay the same.

2. If the total is wrong, the answer is wrong, even when the algebra is right.

B1-B4 · Cumulative B

Worked solutions | Items 19-20

CB-19 · Written response

Given two half-reactions: $H_2O_2 \rightarrow O_2 + 2H^+ + 2e^-$ and $H_2O_2 + 2H^+ + 2e^- \rightarrow 2H_2O$. Write the net equation. What kind of redox reaction is it?

1. Both halves move 2 electrons, so add them as they are. Cancel the $2H^+$ and the $2e^-$ that are on both sides. The net equation is $2H_2O_2 \rightarrow O_2 + 2H_2O$.

2. O starts at -1 and ends at 0 and -2. The same reactant is oxidized and reduced, so this is disproportionation.

CB-20 · Written response

Use these reductions from the Alberta Chemistry 30 Data Booklet, Standard Electrode Potentials: $Ag^+ + e^- \rightarrow Ag$, +0.80 V; $Cu^{2+} + 2e^- \rightarrow Cu$, +0.34 V; $Zn^{2+} + 2e^- \rightarrow Zn$, -0.76 V. Use standard table conditions (25 °C, 1.0 mol/L solutions; pure solids). A student checks the reaction $Cu + Zn^{2+} \rightarrow Cu^{2+} + Zn$ with +0.34 - (-0.76). Give the correct E° for the reaction as written. Explain the student’s mistake.

1. In the reaction as written, Zn^{2+} is the oxidizing agent and Cu is the reducing agent. Use -0.76 - (+0.34) = -1.10 V.

2. The student’s +1.10 V treats Cu^{2+} as the oxidizing agent and Zn as the reducing agent. That is the reverse reaction. A balanced equation does not tell you which direction is spontaneous.