Name:

SCH4U Unit 5 - Practice Questions B [Answer Key]

SECTION 1: Short Answer

For each of the following questions:

i. Identify the reducing agent *(1 mark)*
ii. Identify the oxidizing agent *(1 mark)*
iii. Write balanced oxidation and reduction half-reactions *(2 marks; 1 mark per half-reaction)*

1. $8H^+ + 2MnO_4^-(aq) + 6I^-(aq) \rightarrow 3I_2(s) + 2MnO_2(s) + 2H_2O(el)$

Oxidizing Agent: **MnO4-** **Reducing Agent:** I-

Balanced Half-Reactions

Oxidation Half-Reaction:

$6I^-(aq) \rightarrow 3I_2(s) + 6e^-$

Reduction Half-Reaction:

$8H^+ + 2MnO_4^-(aq) + 6e^- \rightarrow 2MnO_2(s) + 2H_2O(el)$ **It should be 4 H2O not 2**

2. $2H^+ + H_2O_2(el) + 2I^-(aq) \rightarrow I_2(s) + 2H_2O(el)$

Oxidizing Agent: H2O2 **Reducing Agent:** I-

Balanced Half-Reactions

Oxidation Half-Reaction:

$2I^-(aq) \rightarrow I_2(s) + 2e^-$

Reduction Half-Reaction:

$2H^+ + H_2O_2(el) + 2e^- \rightarrow 2H_2O(el)$

SECTION 2: Short Answer

Balance the following equation by the specific method. *(T/I, 2 each) – 1 mark for correct method*
Identify the oxidizing agent and reducing agent. *(A, 1 each)*

3. Balance the following equation using the **oxidation number** method:

$$CuO + NH_3 \rightarrow Cu + H_2O + N_2$$

Oxidizing Agent: CuO **Reducing Agent:** NH3

Balanced Equation:

$Cu\ O + N\,H_3 \rightarrow Cu + H_2O + N_2$
+2 −2 −3 +1 0 +1 −2 0

The change in the oxidation number of the oxidized element N = (0) − (–3) = +3
The change in the oxidation number of the reduced element Cu = (0) − (+2) = –2
The lowest common multiple of 3 and 2 is 6. Thus in the balanced reaction two nitrogen atoms are needed for every three copper atoms. The increase and decrease in oxidation numbers will then be six for both. The partially balanced equation is:
$3CuO + 2NH_3 \rightarrow 3Cu + H_2O + N_2$
The remaining coefficients can be balanced by inspection and the balanced equation is:
$3CuO + 2NH_3 \rightarrow 3Cu + 3H_2O + N_2$

4. Balance the following equation using the **oxidation number** method:

$$H_2S + HNO_3 \rightarrow S + NO + H_2O$$

Oxidizing Agent: **HNO3** **Reducing Agent:** **H2S**

Balanced Equation:

$$\underset{+1\,-2}{H_2} \quad \underset{+1}{S} + \underset{+1\,+5\,-2}{H\,N\,O_3} \rightarrow \underset{0}{S} + \underset{+2\,-2}{N\;O} + \underset{+1}{H_2} \quad \underset{-2}{O}$$

The change in the oxidation number of the oxidized element S = (0) – (–2) = +2
The change in the oxidation number of the reduced element N = (+2) − (+5) = –3
The lowest common multiple of 2 and 3 is 6. Thus in the balanced reaction three sulfur atoms are needed for every two nitrogen atoms. The increase and decrease in oxidation numbers will then be six for both. The partially balanced equation is:

$3H_2S + 2HNO_3 \rightarrow 3S + 2NO + H_2O$

The remaining coefficients can be balanced by inspection and the balanced equation is:

$3H_2S + 2HNO_3 \rightarrow 3S + 2NO + 4H_2O$

5. Balance the following equation using the **half-reactions** method in **acidic solution**:

$$Cr_2O_7^{2-}{}_{(aq)} + Ag_{(s)} \rightarrow Ag^+{}_{(aq)} + Cr^{3+}{}_{(aq)} \qquad (acidic)$$

Oxidizing Agent: **Cr2O72-** **Reducing Agent:** **Ag**

Balanced Equation:

The unbalanced reduction half-cell reaction is: $Cr_2O_7^{2-}{}_{(aq)} \rightarrow Cr^{3+}{}_{(aq)}$

The unbalanced oxidation half-cell reaction is: $Ag_{(s)} \rightarrow Ag^+{}_{(aq)}$

The balanced reduction half-cell reaction is: $6e^- + 14H^+ + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 7H_2O$

The balanced oxidation half-cell reaction is: $Ag \rightarrow Ag^+ + e^-$

Balance the number of electrons in the balanced two half-cell reactions above by multiplying the oxidation half-cell reaction by 6:

$6e^- + 14H^+ + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 7H_2O$

$6Ag \rightarrow 6Ag^+ + 6e^-$

The net algebraic sum of the two half-cell reactions is the balanced equation for the reaction in question:

6 Ag + Cr2O72- + 14 H+ produces 2 Cr3+ + 6 Ag+ + 7 H2O

6. Balance the following equation using the **half-reactions** method in **basic solution**:

$$Cd(s) + NO_3^-(aq) \rightarrow Cd^{2+}(aq) + NO(g)$$

Oxidizing Agent: **NO3-** **Reducing Agent:** Cd

Balanced Equation:

$$2 \times \left(4H^+ + 3e^- + NO_3^-(aq) \rightarrow NO(g) + 2H_2O(el)\right)$$

$$3 \times \left(Cd(s) \rightarrow Cd^{2+}(aq) + 2e^-\right)$$

$$3Cd(s) + 8H^+ + 2NO_3^-(aq) + 8OH^-(aq) \rightarrow 3Cd^{2+}(aq) + 2NO(g) + 4H_2O(el) + 8OH^-(aq)$$

$$3Cd(s) + 8H_2O(el) + 2NO_3^-(aq) \rightarrow 3Cd^{2+}(aq) + 2NO(g) + 4H_2O(el) + 8OH^-(aq)$$

$$3Cd(s) + 4H_2O(el) + 2NO_3^-(aq) \rightarrow 3Cd^{2+}(aq) + 2NO(g) + 8OH^-(aq)$$

SECTION 3: Short Answer

Use the Standard Reduction Table at the end of the test to determine whether each reaction is spontaneous or not spontaneous.

Calculations: 2 each [T/I]
Correct Spontaneity: 1 each [A]

7. Balance the equation and determine whether each reaction is spontaneous or not spontaneous.

$$3Br_{2(l)} + 2Cr^{3+}_{(aq)} + 7H_2O_{(l)} \rightarrow Cr_2O_7^{2-}{}_{(aq)} + 14H^+_{(aq)} + 6Br^-_{(aq)}$$

Reduction half-reaction: $3Br_{2(l)} + 6e^- \rightarrow 6Br^-_{(aq)}$ $E^\circ = +1.06\ V$

Oxidation half-reaction: $2Cr^{3+}_{(aq)} \rightarrow Cr_2O_7^{2-}{}_{(aq)} + 14H^+_{(aq)} + 6e^-$ $E^\circ = -1.33\ V$ this should be **-1.23**

Overall reaction: 3 Br2 + 2 Cr3+ produces 6 Br- + Cr2O72- + 14 H+ $\Delta E^\circ = -0.27\ V$ This **should be -0.16**

ΔE° for the reaction is negative, thus the reaction is nonspontaneous as written.

8. Balance the equation and determine whether each reaction is spontaneous or not spontaneous.

$$Cl_{2(g)} + 2Br^- \rightarrow Br_2 + 2Cl^-$$

Reduction half-reaction: $2Br^- \rightarrow Br_2 + 2e^-$ $E^{\circ +} = -1.06\ V$ **This should be -0.17**

Oxidation half-reaction: $Cl_2 + 2e^- \rightarrow 2Cl^-$ $E^\circ = +1.36$

Overall reaction: 2 Br- + Cl2 produces Br2 + 2 Cl- **The answer is 0.29 V**

ΔE° for the overall reaction is positive, thus the reaction is spontaneous as written.

SECTION 4: Short Answer

9. A galvanic cell is constructed using the following materials:

- Strip of zinc metal
- Strip of iron metal
- $Fe(NO_3)_2$ solution
- $Zn(NO_3)_2$ solution
- $NaNO_3$ (aq)
- 2 beakers
- U-shaped tube
- Connecting wires

a) Explain the process of galvanizing. *(A, 1)*
b) Identify the anode and the cathode. *(A, 1)*
c) What direction will the electrons flow? *(A, 0.5)*
d) Identify the oxidizing agent. *(A, 0.25)*
e) Identify the reducing agent. *(A, 0.25)*
f) Write the equations for the half-reactions in each cell. *(A, 0.5)*
g) Write the net ionic equation for the cell reaction. *(A, 0.5)*

Labeled Diagram (anode, cathode, direction electron flow, etc.):

Galvanizing involves coating an iron object with a layer of zinc. Zinc is a more reactive metal that protects the iron in two ways:
1. the coating prevents the iron from contacting the atmosphere
2. Even if contact occurs, the zinc is more reactive, and so the galvanic cell set up will have zinc as the anode and iron as the anode.

As long as the iron is forced to be the cathode, it will not corrode.

$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s) \quad E^\circ = -0.45V$

$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s) \quad E^\circ = -0.76V$

These two metals will form the following galvanic cell:

$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s) \quad E^\circ = -0.45V$

$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^- \quad E^\circ = +0.76V$

Overall: $Fe^{2+}(aq) + Zn(s) \rightarrow Fe(s) + Zn^{2+}(aq) \quad E^\circ = +0.21V$

Clearly from this spontaneous reaction, it can be seen that the iron will not spontaneously form ions of iron that would cause the iron to corrode.

Oxidizing Agent: _____ **Reducing Agent:** _____

Oxidation Half-Reaction:

Reduction Half-Reaction:

Balanced Net Ionic Equation:

K/U	T/I	A	C
		/4	

SECTION 5: Long Answer

The following questions will be graded according to the following rubric:

Criteria	Level 4	Level 3	Level 2	Level 1
APPLICATION Making connections between science, technology, society, and environment	makes connections between science, technology, society, and the environment with a high degree of effectiveness **(3 marks)**	makes connections between science, technology, society, and the environment with considerable effectiveness **(2 marks)**	makes connections between science, technology, society, and the environment with some effectiveness **(1 mark)**	makes connections between science, technology, society, and the environment with limited effectiveness **(0 - 0.5 mark)**
COMMUNICATION Information and ideas are communicated with complete and correct answers	Information and ideas are communicated clearly and precisely **(2 mark)**	Information and ideas are communicated with considerable clarity and precision **(0.1 marks)**	Information and ideas are communicated with some clarity and precision **(0.5 marks)**	Information and ideas are communicated limited clarity and precision **(0 marks)**

10. In a copper-hydrogen fuel cell, the chemical energy of this compound is converted into electrical energy that can power a vehicle.

(a) Using only the following half-reactions and reduction potentials, write a net reaction equation and determine the approximate potential for the copper-hydrogen fuel cell.

$$Cu^{2+}(aq) + 2\,e^- \rightarrow Cu(s) \quad Er = +0.34\ V$$

$$H_2(g) \rightarrow 2\,H^+(aq) + 2\,e^- \quad Er = 0V$$

(b) Discuss one advantages and one disadvantage of this technology for society.

Cu2+ (aq) + H2 → Cu (s) + 2 H+ (aq)

Ecell = + 0.34 volts

No pollutive byproduct, highly combustible, cost, efficiency

11. How would you explain redox reactions to a chemistry student that has never studied the topic, but was interested in learning about them? Use vocabulary from the unit, but also be sure to give detailed explanations that would allow someone to understand what you are saying.

Answers will vary.

Standard Reduction Potentials:

	$E°_r$ (V)
$F_{2(g)} + 2e^- \rightleftharpoons 2F^-_{(aq)}$	+2.87
$PbO_{2(s)} + SO_{4(aq)}^{2-} + 4H^+_{(aq)} + 2e^- \rightleftharpoons PbSO_{4(s)} + 2H_2O_{(l)}$	+1.69
$MnO^-_{4(aq)} + 8H^+_{(aq)} + 5e^- \rightleftharpoons Mn^{2+}_{(aq)} + 4H_2O_{(l)}$	+1.51
$Au^{3+}_{(aq)} + 3e^- \rightleftharpoons Au_{(s)}$	+1.50
$ClO^-_{4(aq)} + 8H^+_{(aq)} + 8e^- \rightleftharpoons Cl^-_{(aq)} + 4H_2O_{(l)}$	+1.39
$Cl_{2(g)} + 2e^- \rightleftharpoons 2Cl^-_{(aq)}$	+1.36
$2HNO_{2(aq)} + 4H^+_{(aq)} + 4e^- \rightleftharpoons N_2O_{(g)} + 3H_2O_{(l)}$	+1.30
$Cr_2O_{7(aq)}^{2-} + 14H^+_{(aq)} + 6e^- \rightleftharpoons 2Cr^{3+}_{(aq)} + 7H_2O_{(l)}$	+1.23
$O_{2(g)} + 4H^+_{(aq)} + 4e^- \rightleftharpoons 2H_2O_{(l)}$	+1.23
$MnO_{2(s)} + 4H^+_{(aq)} + 2e^- \rightleftharpoons Mn^{2+}_{(aq)} + 2H_2O_{(l)}$	+1.22
$2IO^-_{3(aq)} + 12H^+_{(aq)} + 10e^- \rightleftharpoons I_{2(s)} + 6H_2O_{(l)}$	+1.20
$Br_{2(l)} + 2e^- \rightleftharpoons 2Br^-_{(aq)}$	+1.07
$Hg^{2+}_{(aq)} + 2e^- \rightleftharpoons Hg_{(l)}$	+0.85
$ClO^-_{(aq)} + H_2O_{(l)} + 2e^- \rightleftharpoons Cl^-_{(aq)} + 2OH^-_{(aq)}$	+0.84
$Ag^+_{(aq)} + e^- \rightleftharpoons Ag_{(s)}$	+0.80
$NO^-_{3(aq)} + 2H^+_{(aq)} + e^- \rightleftharpoons NO_{2(g)} + H_2O_{(l)}$	+0.80
$Fe^{3+}_{(aq)} + e^- \rightleftharpoons Fe^{2+}_{(aq)}$	+0.77
$O_{2(g)} + 2H^+_{(aq)} + 2e^- \rightleftharpoons H_2O_{2(l)}$	+0.70
$MnO^-_{4(aq)} + 2H_2O_{(l)} + 3e^- \rightleftharpoons MnO_{2(s)} + 4OH^-_{(aq)}$	+0.60
$I_{2(s)} + 2e^- \rightleftharpoons 2I^-_{(aq)}$	+0.54
$Cu^+_{(aq)} + e^- \rightleftharpoons Cu_{(s)}$	+0.52
$O_{2(g)} + 2H_2O_{(l)} + 4e^- \rightleftharpoons 4OH^-_{(aq)}$	+0.40
$Cu^{2+}_{(aq)} + 2e^- \rightleftharpoons Cu_{(s)}$	+0.34
$SO_{4(aq)}^{2-} + 4H^+_{(aq)} + 2e^- \rightleftharpoons H_2SO_{3(aq)} + H_2O_{(l)}$	+0.17
$Sn^{4+}_{(aq)} + 2e^- \rightleftharpoons Sn^{2+}_{(aq)}$	+0.15
$Cu^{2+}_{(aq)} + e^- \rightleftharpoons Cu^+_{(aq)}$	+0.15
$S_{(s)} + 2H^+_{(aq)} + 2e^- \rightleftharpoons H_2S_{(aq)}$	+0.14
$AgBr_{(s)} + e^- \rightleftharpoons Ag_{(s)} + Br^-_{(aq)}$	+0.07
$2H^+_{(aq)} + 2e^- \rightleftharpoons H_{2(g)}$	0.00
$Pb^{2+}_{(aq)} + 2e^- \rightleftharpoons Pb_{(s)}$	−0.13
$Sn^{2+}_{(aq)} + 2e^- \rightleftharpoons Sn_{(s)}$	−0.14
$AgI_{(s)} + e^- \rightleftharpoons Ag_{(s)} + I^-_{(aq)}$	−0.15
$Ni^{2+}_{(aq)} + 2e^- \rightleftharpoons Ni_{(s)}$	−0.26
$Co^{2+}_{(aq)} + 2e^- \rightleftharpoons Co_{(s)}$	−0.28
$H_3PO_{4(aq)} + 2H^+_{(l)} + 2e^- \rightleftharpoons H_3PO_{3(aq)} + H_2O_{(l)}$	−0.28
$PbSO_{4(s)} + 2e^- \rightleftharpoons Pb_{(s)} + SO_{4(aq)}^{2-}$	−0.36
$Se_{(s)} + 2H^+_{(aq)} + 2e^- \rightleftharpoons H_2Se_{(aq)}$	−0.40
$Cd^{2+}_{(aq)} + 2e^- \rightleftharpoons Cd_{(s)}$	−0.40
$Cr^{3+}_{(aq)} + e^- \rightleftharpoons Cr^{2+}_{(aq)}$	−0.41
$Fe^{2+}_{(aq)} + 2e^- \rightleftharpoons Fe_{(s)}$	−0.44
$Ag_2S_{(s)} + 2e^- \rightleftharpoons 2Ag_{(s)} + S^{2-}_{(aq)}$	−0.69
$Zn^{2+}_{(aq)} + 2e^- \rightleftharpoons Zn_{(s)}$	−0.76
$Te_{(s)} + 2H^+_{(aq)} + 2e^- \rightleftharpoons H_2Te_{(aq)}$	−0.79
$2H_2O_{(l)} + 2e^- \rightleftharpoons H_{2(g)} + 2OH^-_{(aq)}$	−0.83
$Cr^{2+}_{(aq)} + 2e^- \rightleftharpoons Cr_{(s)}$	−0.91
$SO_{4(aq)}^{2-} + H_2O_{(l)} + 2e^- \rightleftharpoons SO_{3(aq)}^{2-} + 2OH^-_{(aq)}$	−0.93
$Al^{3+}_{(aq)} + 3e^- \rightleftharpoons Al_{(s)}$	−1.66
$Mg^{2+}_{(aq)} + 2e^- \rightleftharpoons Mg_{(s)}$	−2.37
$Na^+_{(aq)} + e^- \rightleftharpoons Na_{(s)}$	−2.71
$Ca^{2+}_{(aq)} + 2e^- \rightleftharpoons Ca_{(s)}$	−2.87
$Ba^{2+}_{(aq)} + 2e^- \rightleftharpoons Ba_{(s)}$	−2.91
$K^+_{(aq)} + e^- \rightleftharpoons K_{(s)}$	−2.93
$Li^+_{(aq)} + e^- \rightleftharpoons Li_{(s)}$	−3.04

Periodic Table

Atomic masses are listed underneath each element

1 IA												13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1 **H** 1.01	2 IIA																2 **He** 4.00
3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIIIB	10	11 IB	12 IIB	13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.1	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.39	31 **Ga** 69.72	32 **Ge** 72.61	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.29
55 **Cs** 132.9	56 **Ba** 137.3	57 **La*** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.9	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89 **Ac^** (227)	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (264)	108 **Hs** (265)	109 **Mt** (268)	110 **Ds** (271)	111 **Rg** (272)							

*	58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.3	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
^	90 **Th** 232.0	91 **Pa** (231)	92 **U** 238.0	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)