Test 2 key
Class average = 91(61%) ± 23(15%); high = 139(93%)
A ≥ 118; B ≥ 105; C ≥75; D≥ 55

# \ version	**Version A**	**Version B**
1	C	D
2	C	D
3	E	E
4	E	E
5	E	E
6	E	E
7	D	E
8	E	D
9	E	C
10	B	B
11	E	E
12	C	C
13	E	D
14	B	B
15	B	B
16	D	B
17	D	E
18	D	E
19	D	C
20	C	C
21	B	D

PART II
Problem involving
$\Delta H^\circ_{rxn} = (4 \times 0 + 3 \times 0) - (2 \times (-1676.0)) = +3352.0$ kJ.
$\Delta S^\circ_{rxn} = (4 \times 28.28 + 3 \times 205.15) - (2 \times (50.96)) = +626.65$ J/K
Since the reaction is the exact reverse of a combustion reaction (which is invariably exothermic), it is endothermic, i.e., ΔH°_{rxn} is positive. Since the reaction produces 3 mol of gas per mol of reaction, ΔS°_{rxn} is also expected to be positive.
Now $\Delta S^\circ_{universe} = \Delta S^\circ_{rxn} + \Delta S^\circ_{surroundings} = \Delta S^\circ_{rxn} + (-\Delta H^\circ_{rxn}/T)$. The Second Law of Thermodynamics states that the reaction will be product-favored if $\Delta S^\circ_{universe}$ is > 0. For large T, the second (negative) term will be small and the first (positive) term will dominate, so reaction will be product-favored. For small T, the second term will dominate and reaction will be reactant-favored. Reaction will be product-favored only above a certain temperature.
$\Delta G^\circ = \Delta H^\circ_{rxn} - T\,\Delta S^\circ_{rxn} = 0$

$$\Delta S^\circ_{rxn} = \Delta H^\circ_{rxn}/T \Rightarrow T = \Delta H^\circ_{rxn} / \Delta S^\circ_{rxn} = \frac{3.3520 \times 10^6 J}{626.65 J/K} = 5349.1 \text{ K}$$

Problem involving:

The oxidation process is clearly

$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$

The reduction can be balanced as follows:

(balance O atoms using H_2O) $NO_3^- \rightarrow NO + 2\ H_2O$

(balance H atoms using H^+) $NO_3^- + 4\ H^+ \rightarrow NO + 2\ H_2O$

(balance charge using e^-) $NO_3^- + 4\ H^+ + 3\ e^- \rightarrow NO + 2\ H_2O$

Now multiply oxidation process by 3, reduction by 2, so that e^- cancel, and add:

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

Problem involving: Mn/Mn^{2+} concentration cell:

The value of $E°_{cell}$ is obtained from the equation

$$E°_{cell} = E°_{cathode} - E°_{anode}$$

Depending on the values of the half-potentials, $E°_{cell}$ can certainly be positive.

The Nernst Equation is

$$E_+ = E°_{Mn2+/Mn} - \frac{RT}{nF} \ln Q = E°(Mn) - .06/2 \log(1/1.0x10\text{^-}6)$$

$$E_- = E°_{Mn2+/Mn} - \frac{RT}{nF} \ln Q = E°(Mn) - .06/2 \log(1/1.0) = E°(Mn)$$

$$E_+ - E_- = 0 + (.06/2)(6) = 0.18\ V$$

Essay question involving: batteries and cathodic protection:

a) **dry cell** – cheap materials, relatively non toxic, however, disadvantage is that the potential drops with time and there is a relatively short shelf life.

Hg cell - Potential stays constant during usage and can be very compact in size, however the disadvantage is that the material is toxic and hard to dispose of. Also more expensive that dry cells.

b) **cathodic protection** refers to presence of sacrificial metal like Zn which oxidizes more readily than Fe and makes Fe the cathode thus keeping it from oxidizing.