(Hint: ln 2 = 0.6931... ~= 0.7)

1. Balance the following half reaction in an acid. How many hydrogen ions are needed?
$Cr(OH)_3 \rightarrow CrO_4^{2-}$

a. 5
b. 4
c. 3
d. 2
e. 1

$Cr(OH)_3 + H_2O \dashrightarrow CrO_4^{2-} + 5H^+ + 3e^-$

2. The reaction below occurs in a(an) _____ cell and the sign of the anode is _____.
$Cu_{(s)} + 2Ag^+ \rightarrow CU^{2+} + 2Ag_{(s)}$

a. Electrochemical, Positive
b. Voltaic, Positive
c. Electrochemical, Negative
d. Galvanic, Negative

E = 0.8 - (0.2) = 0.6V. The cell is therefore voltaic. The anode loses electrons regardless of whether not you have a galvanic or electrochemical cell. It is therefore designated to have negative sign due to a lose of electrons

3. Which statements are true in regards to a table of standard half cell reduction potentials?

I. The reactants of the reaction are oxidizing agents
II. The more positive the potential the better the reducing agent
III. The reactions shown are reductions
IV. The oxidizing number of the products is smaller than the reactants

a. I, III, IV
b. I, II, III, IV
c. II, III
d. II, IV

The reactants in a reduction are oxidizing agents. The reactants in oxidations are reducing agents.

4. If a dead battery has a ratio of 2 for $[Fe^{2+}]/[Cd^{2+}]$, what is the standard cell potential? (Hint: log(2) = 0.301)

a. 0.36 V
b. 0.33 V
c. -0.33 V
d. -0.36 V

$E_{cell} = E^o_{cell} + 0.05916/n * \log([products]/[reactants])$
$0 = X + 0.05916/2 * \log(2)$
$X = -0.331$ V

5. Rank the following from weakest to strongest oxidizing agent: Li^+, K^+, Mg^{+2} , Zn^{+2}

$Li^+ + e^- \rightarrow Li$ -3.1 V
$K^+ + e^- \rightarrow K$ -2.9 V
$Mg^{+2} + 2e^- \rightarrow Mg$ -2.4 V
$Zn^{+2} + 2e^- \rightarrow Zn$ -0.76 V

a. $Li^+ < K^+ < Mg^{2+} < Zn^{2+}$
b. $Li^+ < Mg^{+2} < K^+ < Zn^{2+}$
c. $Zn^{+2} < Mg^{+2} < K^+ < Li^+$

d. $Zn^{+2} < Mg^{+2} < K^{+} < Li^{+}$

The higher the reduction potential, the stronger the oxidizing agent.

6. How many moles of Al^{3+} were needed to produce 4 moles of Al when 0.5 faraday of charge passes through a cell?

a. 0.2 mol Al^{3+}
a. 4 mol mol Al^{3+}
b. 1 mol^{3+}
c. 0.1 moles Al^{3+}

1 faraday corresponds to 1 mol e-. Therefore, .5 faradays is due to .5 mol e-. In order to produce Al from Al^{3+} 3 electrons are needed.
x moles Al^{3+} = (.5 mol e-/4 mol Al) = .11 moles Al^{3+}

7. What current is needed to produce 98.5 g of solid gold from Au+ in 2 hours?

a. 6.7 A
b. 24.1 kA
c. 804.0 A
d. 7.0 kA

I = (Moles of Product)(Moles of electrons)(Faraday)/time
I = 0.5 moles * 1 e- *96,485 / (7200 sec)
I = 6.7 A

8. The following reaction is at equilibrium. If $[Ag^{+}] = 1x10^{-6}$ M, what is $[Cu^{2+}]$?

$Cu^{2+} + 2Ag(s) \rightarrow Cu_{(s)} + 2Ag^{+}$

a. $5x10^{-9}$ M
b. $5x10^{-15}$ M
c. $2x10^{8}$ M
d. 5x10-7 M

E^{o} = (0.2) - .8 = -0.6V
$E = E^{o} - (0.05916/n)*\log K$
$0 = E^{o} - (0.05916/n)*\log K$
$-0.6V = (0.05916/n)*\log([Ag^{+}]^{2}/[Cu2+])$

$(1x10^{-6}\ M)^{2}/[Cu2+] = 10\text{^}(2*-0.6/0.05916)$

9. Which of the following is not true about nickel-metal hydride batteries?

a. They are not rechargeable
b. Nickel is the cathode
c. They have 2-3 times more capacity than a NiCd battery of equivalent size.
d. A hydrogen absorbing alloy is the anode

10. Consider the reaction below:

$2A + B \rightarrow \frac{1}{2}C$

If [C] increases from 0 M to 0.5 M in the course of 1 minute, what [B] remains after 30 seconds if it is initially 1 M?

a. 0.5 M
b. 0 M
c. 1 M
d. 1.5 M

For this reaction, becuse the stoichiometric ratio of B to C is 2:1, B will be used at twice the rate C is produced. So, of [C] increases by 0.5 M in 1 minute, [B] will decrease by twice that amount, 1 M, in 1 minute. After only 30 seconds, it will be half as much.

11. Consider the data below:

Experiment	[A] (M)	[B] (M)	[C] (M)	initial rate ($M \cdot s^{-1}$)
1	1	0.5	2	0.4
2	2	3	2	0.8
3	1	0.5	1	0.8
4	2	0.5	4	0.4

If only these species are pertinent, what is the overall order of the reaction?

a. 1st
b. 3rd
c. 0
d. 2nd

In general, $([A]_x/[A]_y)^a \cdot ([B]_x/[B]_y)^b \cdot ([C]_x/[C]_y)^c = (rate_x/rate_y)$
The trick to making use of this relationship is to pick sets of experiments (x and y), where there is only one unknown value, the order with respect to a single species. For example in experiments 1 and 3, only [C] is varied, so the expression reduces to:
$([C]_x/[C]_y)^c = (rate_x/rate_y)$
$(2/1)^c = (0.4/0.8)$
$c = -1$
Now that we know this, solving other such expressions is easier, because knowing c, the order with respect to C, allows us to include it in solving other expressions.
One can also take the approach of inference. For example, In experiments 1 and 4 the species [B] is unchanged and both [A] and [C] are doubled. The rate is unchanged. Having already determined that the reaction is -1st order with respect to C, we can infer that the reaction must be 1st order with respect to A, such that the two effects of doubling both species cancel out and the observed initial rate remains unchanged.
I'll leave it to you to determine the reaction order with respect to B.

12. Consider the following elementary reaction:

$O(g) + O(g) \rightarrow O_2(g)$

If $[O]_o$ is 4 atm and after 3 seconds [O] has decreased to 1 atm, what is the value of k, the rate constant, for this reaction?

a. 0.250 $M^{-1} \cdot s^{-1}$
b. 0.375 $M^{-1} \cdot s^{-1}$
c. 0.500 $M^{-1} \cdot s^{-1}$
d. 0.125 $M^{-1} \cdot s^{-1}$

Because the reaction is an elementary reaction, we can infer that it must be second order, as O must collide with another O to make O_2.
$[O]^{-1} = [O]_o^{-1} + akt$
$1^{-1} = 4^{-1} + 2k3$
$0.75 = 6k$
$k = 0.125\ M^{-1} \cdot s^{-1}$

13. integrated rate law calculation (half life)
Consider the following reaction:

$H_2O_2(aq) \rightarrow H_2O(l) + \frac{1}{2}O_2(aq)$

If, at a certain temperature and in the presence of a catalyst, the rate constant for this decomposition is 0.00726 s^{-1}, what is the apporximate half life of hydrogen peroxide?
(Note: the actual catalyzed rate of decomposition of hydrogen peroxide is not first order and

is in fact rather complicated, but assume it is first order here to make the calculations doable.)

a. 50 seconds
b. 100 seconds
c. 200 seconds
d. 500 seconds
e. 1000 seconds

$t_{½}$ = ln 2/ak
$t_{½}$ = 0.6931/0.00726 s^{-1}

14. In a straight-line plot for a 2nd order reaction, the x-axis has units of _____ and the y-intercept is the _____ of an initial concentration.

a. concentration, natural log
b. concentration, inverse
c. time, natural log
d. time, inverse

15. All of the the factors below can increase the rate of a reaction. However, one of them is not considered in collision theory. Which is it?

a. increased reactant concentration
b. addition of a catalyst
c. increased temperature
d. all are considered in collision theory

Collision theory does not speculate about mechanisms and thus does not concern itself with the impact of catalysts on rates.

16 According to transition state theory, a set of chemical species that are involved in an equilbrium will be predcited to spend the least amount of time as _____.

a. reactants
b. products
c. transition states
d. transition state theory doesn't allow for such predictions

The most energetic species is by definition the least stable and thus the least populated.

17. combined Arrhenius calculation
Consider the combined Arrhenius equation. If, hypothetically, a reaction had an activation energy of zero, what would be the result?

a. Nothing. The reaction would still get faster as temperature was increased.
b. The reaction would infinitely fast, k = ∞, at all temperatures.
c. The rate constant, k, would asymptotically approach zero as T approached infinity.
d. The reaction would have the same rate at all temperatures.

An activation energy of zero would make the entire right hand side of the combined Arrhenius equation zero, the only way to make the left side equal would be for k to b the same at all temperatures, as ln 1 = 0.

18. reaction mechanisms
A reaction mechanism _____

a. is only determined by looking at a balanced net reaction.
b. can be predicted using transition state theory.
c. must be determined experimentally.
d. can be determined using any of these methods.

There is no way, just from looking at a reaction, to know the mechanism. A mechanism can only be determined experimentally.

19. The energy profile (a.k.a. reaction coordinate diagram) of a 3-step mechanism describing a non-spontaneous process, will have 3 peaks and at least _____ of the reverse steps must have a _____ activation energy than its corresponding forward step.
   a. 1, higher
   b. 1, lower
   c. 2, higher
   d. 2, lower

Each step will have a transition state, so the diagram will exhibit 3 peaks. In order for the reaction to be non-spontaneous overall, at least one of the reverse steps must be faster than its corresponding forward step. This implies a lower activation energy.

20. A lot of the famous catalyst discussed in your course notes and lectures are or contain which of the following?
   a. alkali metals
   b. halogens
   c. oxygen
   d. transition metals
   e. phosphorous

Enough said, really.

21. Which of the following statements could explain why alkali metals explode in water?
   a. Alkali metals have low boiling points.
   b. Alkali metals have an s^2 configuration that makes them highly reactive.
   c. Alkali metals have a low ionization energy.
   d. Alkali metals do not explode in water because they are relatively stable metals.

Because alkali metals have a low ionization energy, they can be easily oxidized by water.

22. What statement about Calcium is false?
   a. It is an alkali earth metal.
   b. It is found in hard materials like concrete.
   c. It is more likely to be reduced.
   d. It reacts in hot water to form hydrogen gas.

Calcium will be oxidized to Ca^{++}.

23. Which statement about the B family is true?
   a. They have an electronegativity around 1.5 or lower
   b. They form three covalent bonds.
   c. They never exist in an octet configuration.
   d. They have strictly non-metallic character.

The B family has an electronegativity of 2.0 or lower. Elements always want to achieve an octet configuration. The B family has metallic and non-metallic character.

24. Why is the N group important?
   a. They are used to make strong structural materials.
   b. They are used in fertilizers.
   c. They frequently appear in gems.
   d. They are useful in batteries.

Multiple members of the N group are used in fertilizers, such as N in ammonia and P in phosphates.

25. Which of the following is an allotrope of Carbon?
   a. Carbonate
   b. Oxygen
   c. Carbon dioxide

d. Buckministerfullerene (A "Bucky Ball")

Allotropes are structurally different forms of an element. Buckministerfullerene is C_{60}.

26. What happens in reactions with oxygen?
    a. They primarily form salts.
    b. They drive everything to a lower oxidation state.
    c. They drive everything to a higher oxidation state.
    d. Nothing. Oxygen is unreactive.

Combining oxygen with a compound will result in an increased oxidation state. (Think of combustion reactions, hydrocarbons --> carbon dioxide.)

27. Which element would you rather have in a balloon at a birthday party?
    a. Neon
    b. Oxygen
    c. Hydrogen
    d. Potassium

Hydrogen and oxygen gas would be too reactive to be safe near birthday candles. Potassium is a sold. Because neon is a halogen, it would be unreactive.

28. Which of the following statements is false?
    a. Hydrochloric acid is produced using the Ostwald process.
    b. The Hall process produces aluminum.
    c. Alumina is formed in the Bayer process.
    d. The Haber process involves nitrogen fixation.

The Ostwald process produces nitric acid, HNO_3.

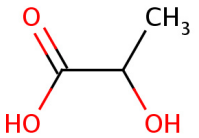
29. Which of the following sets is incorrectly matched?
    a. Emerald - beryllium oxide and chromium ions
    b. Diamond - silicon
    c. Ruby - aluminum oxide and chromium ions
    d. Sapphire - aluminum oxide, iron ions, and titanium ions
    e. Topaz - aluminum oxide and iron ions

Diamond - carbon

30. how many isomers does C_5H_{12} have?
    a. 1
    b. 2
    c. 3
    d. 4

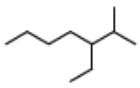
the three structural isomer for C_5H_{12} are:

31. What is the IUPAC name for the following structure?

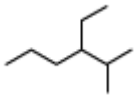


a. 1-carboxylic acid 2-propanol
b. 2-propanol carboxylic acid
c. 2-hydroxyl 3-carboxyl propane
d. 2-hydroxypropanoic acid

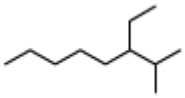
32. which of the following is the correct structure for 3-ethyl-2-methyloctane?
a.



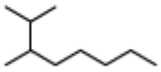
b.



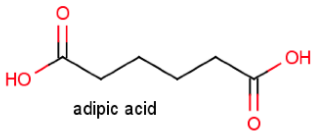
c.

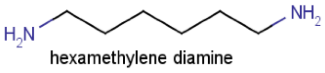


d.



33. Nylon is formed by condensation between the molecules shown below:





which functional groups react? what type of bond is formed in the condensation reaction?
a. alcohol, amide; ester
b. alcohol, nitro; carboxyl
c. carboxylic acid, nitryl; ether
d. carboxylic acid, amine; amide

34. All of the following molecules contains a carboxyl functional group except:
a. fatty acid
b. nucleic acid
c. amino acid
d. all of the above contains a carboxylic acid group
nucleic acid contains a phosphoryl group, not carboxyl group.

35. which of the following biomolecules contains an ether bond?

a. sugar
b. protein
c. fatty acid
d. glycerol