2015 AP FRQ

- Teacher Solutions +
  Guesstimate # of
  pts for each problem

① a) i) $E_{cell} = E_{cath} - E_{anode}$

$= +0.34 - (-1.31) = +1.65\,V$

Zn is oxidized = anode

O is reduced = cathode

ii) OH^- flows to the left, towards the anode

b) i) increases

ii) the Zn(s) electrode gains mass as oxygen reacts w/ it to form ZnO(s)

c) i) lower

ii) lower pressure will drive rxn left towards more gas due to Le'Chatlier's principle

d) $Na \rightarrow Na^+ + e^-$

$\frac{1\,g\,Na \,|\, 1\,mol\,e^-}{|\,22.9\,g} = 0.043\,mol\,e^-$

$Ca \rightarrow Ca^{2+} + 2e^-$

$\frac{1\,g\,Ca \,|\, 2\,mol\,e^-}{|\,40.08\,g} = 0.050\,mol\,e^-$

★ Ca transfers more e^-

e) i) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10}$

ii) 4s

Points Guesstimate 2, 2, 2, 2, 2

(2)

a) i) Water vapor pressure = $35.7\ \text{torr} \times \frac{1\ \text{atm}}{760\ \text{torr}} = 0.0470\ \text{atm}$

$P_{ethene} = P_{TOTAL} - P_{H_2O} = 0.822\text{atm} - 0.0470\text{atm}$

$= 0.775\text{atm}$

$PV = nRT \Rightarrow (0.775\text{atm})(.0854\ L) = n(.0821)(305K)$

$n = 0.00264$ mol ethene

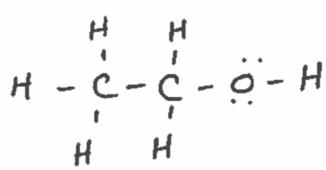
ii) $\frac{0.200\text{g ethanol}}{} \times \frac{1\text{ mol}}{46.1\text{g}} = .00434\text{mol}$

Ratio is 1:1 so .00434 mol ethanol = .00434 mol ethene

b) $\%\ \text{yield} = \frac{.00264\text{mol}}{.00434\text{mol}} \times 100 = 60.8\%$

c) $\Delta G = \Delta H - T\Delta S = 45.5 - (298)\left(\frac{126}{1000}\right) = +7.95\ \text{kJ/mol}$

A positive ΔG will have a $K<1$ so the student's claim is correct since the rxn is thermodynamically unfavored and will produce relatively few products.

d) 

e) · 4 e^- domains around O gives tetrahedral geometry

· w/ 2 lone pairs, it will make angle a little less than 109.5°

· something around 105°

f) - C_2H_4 is nonpolar and has only weak LDF. Does not dissolve.

- C_2H_5OH is polar and can H-bond w/ water forming relatively strong IMF w/ water allowing it to dissolve.

Points Guesstimate 2, 1, 3, 1, 1, 2

③ a) $C_6H_7O_2^- + H^+ \rightleftarrows C_6H_8O_2$

b) $\frac{29.95\,mL}{} \Big| \frac{1\,L}{1000\,mL} \Big| \frac{1.25\,mol\ HCl}{1\,L} \Big| \frac{1\,mol\ KC_6H_7O_2}{1\,mol\ HCl} = 0.03744\ mol\ KC_6H_7O_2$

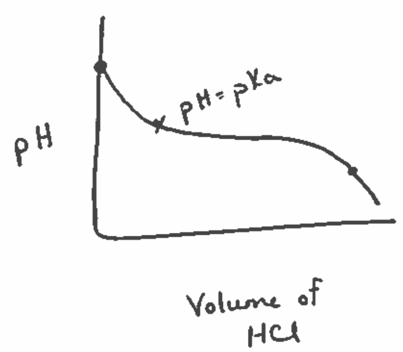
$[KC_6H_7O_2] = \frac{.03744\,mol}{.045\,L} = 0.832\,M$

c) Thymol blue. An indicator should be chosen that changes color close to the equivalence + one w/ a pKa close to the pH at that pt will do so.

d) $pH = pKa + \log\frac{[base]}{[acid]}$ and halfway to the equiv. pt pH = pKa

$pH = -\log(1.7\times10^{-5}) = 4.77$

e)



f) Since the pH of the soft drink is after the halfway pt of the titration, more than 50% of $KC_6H_7O_2$ must have been used up at this pt, and therefore the product ($C_6H_8O_2$), is present in ↑ conc.

Points Guesstimate 1, 1, 2, 1, 3, 2

(4)

a) $Ca(OH)_2\ (s) \rightleftharpoons Ca^{2+}\ (aq) + 2OH^-\ (aq)$

b)

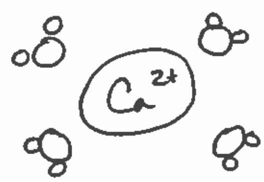
	$Ca(OH)_2$	Ca^{2+}	$2OH^-$
I	–	.1M	
C	–	–	+2x
E	–	.1M	2x

$K_{sp} = 1.3\times10^{-6} = [Ca^{2+}][OH^-]^2 = (.1)(2x)^2$

$1.3\times10^{-6} = .4x^2$

$x = 1.8\times10^{-3}\ M$

c)



Points Guesstimate 1, 2, 1

(5)

a) 1st order since the graph ln(absorbance) vs. time is linear

b) Increase [food coloring]
- w/ a greater starting conc of food coloring, the time taken to reach an unacceptable absorbance will be longer since there is a constant half-life for the rxn

c) Red and blue have different wavelengths so a diff. wavelength for the spectrophotometer would need to be chosen to account for the fact that blue and red food coloring absorb light in diff. parts of the electromagnetic spectrum.

Points Guesstimate 1, 2, 1

⑥ a) LiF and LiI

LiF - small cation, paired w/ a relatively small anion, has a m.p. of 845°C, which is relatively high, and suggests a higher degree of ionic character

Compared to:

LiI - (same) small cation, paired w/ a relatively large anion, has a m.p. of 449°C, which is relatively low + suggests a ↑ degree of covalent character

* Could mention Coulomb's Law here in terms of charge all being the same. As distance btw bond increases, denominator gets larger. Large denominator = smaller ionic force

b) - NaF, the salt of a strong base (NaOH) and a weak acid (HF)

$$NaF + H_2O \rightleftharpoons HF + NaOH$$

$$\cancel{Na^+} + F^- + H_2O \rightleftharpoons HF + \cancel{Na^+} + OH^-$$

$$F^- + H_2O \rightleftharpoons HF + OH^-$$

- LiF would also work for the same reasoning.

Points Guesstimate 2, 2

⑦

a) Heat of Al : $q = nc\Delta T = (1\ mol)(24\ J/mol\cdot K)(933 - 298\ K) = 15240\ J$

$= 15.24\ kJ$

Melt the Al : $q = n\Delta H = (1\ mol)(10.7\ kJ/mol) = 10.7\ kJ$

Total energy is the sum : 15.24 kJ
+ 10.7 kJ

25.9 kJ

b) Energy required for extraction is 1675 kJ/2 mol Al

= 837 kJ/mol

Comparing this value to part A, recycling uses less energy per mole of Al than extraction does.

Points Guesstimate 2, 2