**\*format might be weird because i wrote a lot of these in various documents and just copied them over. Some stuff especially exponents and molecular formulas will look weird. I think it should be readable if there is question context\***

**Explosive Fertilizer [15 pts]**

**21.** From the given data, we see the enthalpies of formation of the relevant species (in kJ/mol)

H2O(g): -241.8

N2O(g): 82.1

NH4NO3(s): -365.6

By Hess' law we can find the enthalpy of the given reaction (where mol\_rxn is equal to mol\_NH4NO3): ΔH = [ 2(-241.8 kJ/mol) + 82.1 kJ/mol ] - [ -365.6 kJ/mol ] = -35.9 kJ/mol

[2 for work 1 for right answer]

**22.** Ammonium nitrate is 80.0 g/mol: (2750 metric tons) / (80.0 g/mol) = 34.4 Mmol (34.4 Mmol) (-35.9 kJ/mol) = -1.23 TJ

So 1.23 TJ of energy released assuming constant pressure

[2 for work 1 for right answer]

**23.** Heat of vaporization of liquid water is +40.7 kJ/mol, its specific heat is 75.3 J/(mol K), its molar mass is 18.0 g/mol and its density is 1.00 g/mL. If we start with water at room temperature (25 °C), then the heat required for heating and vaporization is (75 K)(75.3 J/(K mol)) + (40.7 kJ/mol) = 46.3 kJ/mol

(1.23 PJ) / (46.3 kJ/mol) = 26.6 Mmol water

(26.6 Mmol) (18 g/mol) = 479 Mg water

(479 Mg) / (1 g/mL) = 479 kL water

So 479,000 L of room temperature water could be vaporized.

[2 for work 1 for right answer]

**24**. ΔG = ΔH - TΔS, so if ΔS is positive, then ΔG will decrease as T increases.

[anything along these lines is okay]

**25.** Prior to the reaction, we can use ideal gas law to calculate moles of atmospheric gases at 25 °C:

n = PV/RT = (1 atm)(19.8 km^3)/(R)(298 K) = 810 Gmol

From the balanced equation, we see that 3 mol of gas is produced for every 1 mol of NH4NO3 that decomposes, so (34.4 Mmol)(3) = 103 Mmol of gas is produced. Therefore, as no new oxygen is produced, the percentage of oxygen in the atmosphere changes by a factor of (810 Gmol)/(810 Gmol + 103 Mmol) = 0.9999; the composition of atmospheric gases is essentially unchanged.

[2 for work 2 for right answer with numerical backing otherwise max pts is 2]

**MCB a Problem Oriented Guide [21]**

**26** 1) CaF2 (s) -> Ca2+ (aq) + 2 F-(aq)

H+ (aq) + F- (aq) -> HF (aq)

a. Both equations for 1 pt, states for another pt

**27** 2) Increase, because H+ reacts with F- , thus shifting the equilibrium for the dissolution of calcium fluoride to the right

a. any explanation with some form Le Chatelier’s principle receives full credit

**28** 3) Ksp = [Ca2+][F-]^2 Ka = [H+][F-]/[HF] Kw = [H+][OH-] [each one is worth 1 pt]

a. each one is worth 1 pt

**29** 4) [F-] + [HF] = 2[Ca2+]

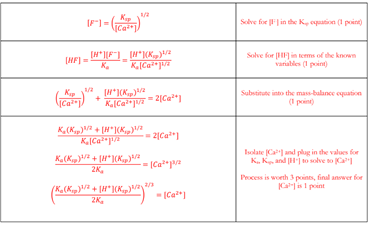
a. Has to be exact for full credit

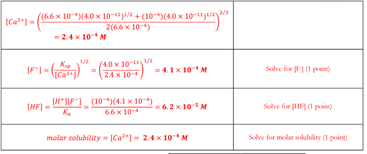
**30** 5) The Charge Balance one

a. The reason is that you can’t account for the amount of positive charges because you can’t make an assumption about the initial amount of positive charge.

**31** 6) [H+] = 10-pH M = 10-4.00 M = 1.0 × 10-4 M

a. No partial credit

**32** 7) 



**Crooked Coffee [21 pts]**

**~this one is text heavy so answers might vary~**

**33** 1) This process works because there is some equilibrium between the amounts of caffeine and oils/flavors present in the beans and in the solution. In the second round of heating, there is a lot of caffeine in the beans but none in the water, so the caffeine will be extracted and dissolve in the water until this equilibrium is reached. However, the water already contains a significant amount of oils/flavor molecules so the solution is nearly saturated with respect to these molecules, and there will not be a huge loss of oils/flavors.

**34** 2) The Bronsted-Lowry definition of acids and bases tells us that acids are proton donors and bases are proton acceptors, therefore we should add a base

**35** 3) H2O can be eliminated because we’ve already established that water will dissolve all of the components of the solution. CH3CH2OH could potentially be useful in dissolving caffeine since it’s a polar molecule, however ethanol is miscible with water and we would not be able to separate the two solutions. That leaves CH2Cl2 which is a polar solvent that is not miscible with water and is therefore perfect for dissolving caffeine. (Nile red did a video on this!<https://www.bing.com/videos/search?q=nile+red+caffeine&&view=detail&mid=7BF6D8027C744FCE7E8F7BF6D8027C744FCE7E8F&&FORM=VRDGAR>)

**36** 4) The boiling point of a substance is defined as the temperature at which its vapor pressure becomes equal to the external pressure. Therefore, in order to lower the boiling point of a substance we can either find a way to change the vapor pressure of the substance or the external pressure. The best option is to change the external pressure, which we can accomplish by putting the solution under vacuum. This lowers the external pressure and therefore the boiling point.

**37** 5) CH4 (g)+2 Cl2 (g) -> CH2Cl2 (l) +2HCl (aq)

Need states for full crediut

**38** 6) First write the balanced equation for the combustion of ethyl acetate:

CH3CO2C2H5 (l) +5O2 (g) ->4CO2 (g) +4H2O (l)

Need states

Then calculate how many moles of products will be formed

30 g CH3CO2C2H5 x (1 mol CH3CO2C2H5/88.11g) = 0.34 mol CH3CO2C2H5 0.34 mol CH3CO2C2H5 x (4 mol CO2/1 mol CH3CO2C2H5) = 1.36 mol CO2 produced 0.34 mol CH3CO2C2H5 x (4 mol H2O /1 mol CH3CO2C2H5) = 1.36 mol H2O produced

At 120 C, both products will be in the gas phase, so we have 2.72 mol of gas

Then just ideal gas law

PV=nRT (1 atm)V=(2.72 mol)(0.08206 L\*atm/mol\*K)(393 K)

V = 87.7 L of gas

The steps are worth 3 pts the final snwer is worth 2

**Classical Acid Base Chem Problem [21 pts]**

**39**

H2SO4 → H+ + - HSO4

[H2SO4] = 0

2nd ionization [H+ ][ 2- SO4 ] / [ - HSO4 ] = K2 = 1.2×10-2

Mass balance [H2SO4] + [ - HSO4 ] + [ 2- SO4 ] = 1.0×10-7

Charge balance: [H+ ] = [ - HSO4 ] + 2 [ 2- SO4 ] + [OH- ]

Since solution is dilute ionization is intensified

[H ] = 2×10-7

[ 2- SO4 ] / [ - HSO4 ] = 6×104

[ - HSO4 ] = 0

[ 2- SO4 ] = 1.0×10-7

[H+ ] = (2×10-7) + 10-14 / [H+ ]

[H+ ] = 2.4×10-7 This means the pH is 6.6

[OH- ] = 1×10-14 / (2.4×10-7) = 4.1×10-8

[ - HSO4 ] = [H+ ] [ 2- SO4 ] / K2 = (2.4×10-7) × (1.0×10-7) / (1.2×10-2) = 2.0×10-12

Each answer is 1 pt, and the MCB equation (or other equilibrium equation) is worth 3 pts.

You can check the answer with MCB once again.

2.4×10-7 ≈ (2.0×10-12) + 2 (1.0×10-7) + (4.1×10-8)

0 + 2.0×10-12 + 1.0×10-7 ≈ 1.0×10-7

**40**

n(H3PO4) = 0.85 × 3.48 cm3 × 1.69 g cm-3 × 1 mol / 98.00 g × 1000 = 51.0 mmol

1:1 mixture of H PO 2 4 − and 2 HPO4 − would have pH = pK2 = 7.20.

To move the pH up you need more 2 HPO4 −

H3PO4 + OH- → H PO 2 4 − + H2O

H2PO4 - + OH- → 2 HPO4 − + H2O

51.0 mmol / 0.80 mol dm-3 = 63.75 cm3

H PO 2 4 − + OH- → 2 HPO4 −

Initial mmol 51.0 x 0

Final mmol 51.0 – x 0 x

pH = pK2 + log [ 2 HPO4 − ] / [H PO 2 4 − ]

7.40 = 7.20 + log {x / (51.0 – x)}

x = 31.27 mmol

31.27 mmol / 0.80 mol dm-3 = 39.09 cm3

NaOH = 63.75 + 39.09 = 102.84 cm3 ≈ 103 cm3

2 pts for the answer

4 pts for work (ice tables and conversions)

**41**

Pka = 3.52

Ph = pka + log[A-]/[HA]

[A-]/[HA] = 10^pH-pKa

In blood pH = 7.4

[A]/[HA] = 10^7.4-3.52 = 7586

Total aspirin 7586 + 1 = 7587

Because starting is 1

In stomach pH = 2

[A-]/[HA] = 10^2-3.52 = 3.02\*10^-2

Total aspirin 2.03\*10^-3 + 1 = 1.03

Ratio is 7587/1.03 = 7400

1 pt for finding aspirin in the blood

1 pt for finding aspirin in the stomach

1 pt for diving them to find ratio

2 pts for associated HH equations.