20F-CHEM20A-1 Final Section 1

LEONARD CHEN

TOTAL POINTS

156 / 175

QUESTION 1

1 Q1 **35 / 35**

- ✓ + **2 pts** a. levels correct
- ✓ + **2 pts** a. labels correct
- ✓ + **2 pts** a. electrons correct
- ✓ + **2 pts** a. molecular electronic configuration
- ✓ + **2 pts** b. i) d-electrons all correct
- ✓ + **4 pts** b. i) splitting levels correct
- ✓ + **2 pts** b. i) labels correct
- ✓ + **4 pts** b. ii) CFSE equation correct
- ✓ + **4 pts** b. ii) CFSE = $$-1.2\Delta_0$$
- ✓ + **2 pts** b. iii) paramagnetic
- ✓ + **2 pts** b. iii) unpaired electrons
- ✓ + **3 pts** c. conclusion: Yes
- ✓ + **2 pts** c. equations correct
- ✓ + **2 pts** c. all correct
- \+ **0 pts** missing the problem

QUESTION 2

2 Q2 **23 / 32**

- \+ **12 pts** Correct a
- ✓ + **8 pts** correct b
- ✓ + **12 pts** correct c
- ✓ + **6 pts** correct handling of H and C in a
- \+ **4 pts** partial credit for b
- \+ **9 pts** correct handling of C and H and ratio conversion
- \+ **0 pts** incorrect
- \+ **6 pts** 2 valid structures in c
- \+ **3 pts** correct mol for oxygen
- \+ **9 pts** 3 valid structures
- **- 3** Point adjustment

  wrong ketone

QUESTION 3

3 Q3 **26 / 26**

- ✓ + **26 pts** Correct A and B
- \+ **16 pts** Correct A
- \+ **12 pts** Used wrong mass but everything else was correct.
- \+ **8 pts** Found delta E then didn't use MV=DeltaE/C
- \+ **5 pts** General idea for A
- \+ **10 pts** B is correct
- \+ **5 pts** General idea for B
- \+ **0 pts** Nothing was submitted
- \+ **8 pts** Converted wrong for B.
- \- **1 pts** Wrong sign
- \+ **0 pts** Question is wrong.
- \+ **2 pts** Wrote the correct equations to use.

QUESTION 4

4 Q4 **34 / 34**

- ✓ - **0 pts** All correct

(a)

- \- **2 pts** 3p fills before 4s then 3d
- \- **2 pts** $$[Ne]=[He]2s^22p^6$$ so needs to be 3s 3p or [He]
- \- **2 pts** 2p fills before 3s
- \- **2 pts** $$[Kr]=[Ar]4s^23d^{10}4p^6$$ so needs 5s 4d or [Ar]

(b)

- \- **2 pts** $$Zn^{2+}= [Ar]3d^{10}$$
- \- **2 pts** $$Cr^{3+}= [Ar]3d^{3}$$
- \- **2 pts** $$Pt^{2+}= [Xe]4f^{14}5d^{8}$$
- \- **2 pts** $$Ag^{+}= [Kr]4d^{10}$$
- \- **2 pts** $$Ti^{4+}= [Ar] or [Ne]3s^23p^6$$

(c)

- \- **2 pts** $$I^{-}= [Xe] or [Kr]5s^24d^{10}5p^6$$
- \- **2 pts** $$Mg^{2+}= [Ne] or [He]2s^22p^6$$

- **2 pts** $$Al^{3+}= [Ne] or [He]2s^22p^6$$
- **2 pts** $$S^{2-}= [Ar] or [Ne]3s^23p^6$$
- **2 pts** $$K^{+}= [Ar] or [Ne]3s^23p^6$$

(d)

- **2 pts** Rh $$[Kr]5s^14d^8$$ or $$[Kr]5s^24d^7$$
- **2 pts** Na $$1s^22s^22p^63s^1$$
- **2 pts** Se $$[Ar]3d^{10}4s^24p^4$$

- **3 pts** (d) element not identified or configuration not given
- **34 pts** No answer submitted

\+ **0 pts** Graded

QUESTION 5

5 Q5 **18 / 28**

✓ + **6 pts** **Part a: 3 structures correct**

\+ **4 pts** Part a: 2 structures correct

\+ **2 pts** Part a: 1 structure correct

✓ + **2 pts** **part a: 3 geometric isomer**

✓ + **2 pts** **part a: no enantiomers**

✓ + **4 pts** **part b i. No isomers**

✓ + **4 pts** **part b i. Explanation is correct (en and cl make binding sites equivalent, achiral, bonds have same angle, etc)**

\+ **2 pts** part b i. Explanation is partially correct.

\+ **4 pts** part b ii. No isomers

\+ **6 pts** part b ii. Explanation is correct (en makes two binding sites equivalent, rotation will transform the structure, etc)

\+ **3 pts** part b ii. Explanation is partially correct

\+ **0 pts** incorrect

QUESTION 6

6 Q6 **20 / 20**

✓ + **10 pts** **Part a correct 5.53kg or 5530g**

✓ + **10 pts** **Part b correct 3.23kg NH3 and 617g of C3H6 left**

\+ **5 pts** Partial credit for part a setup

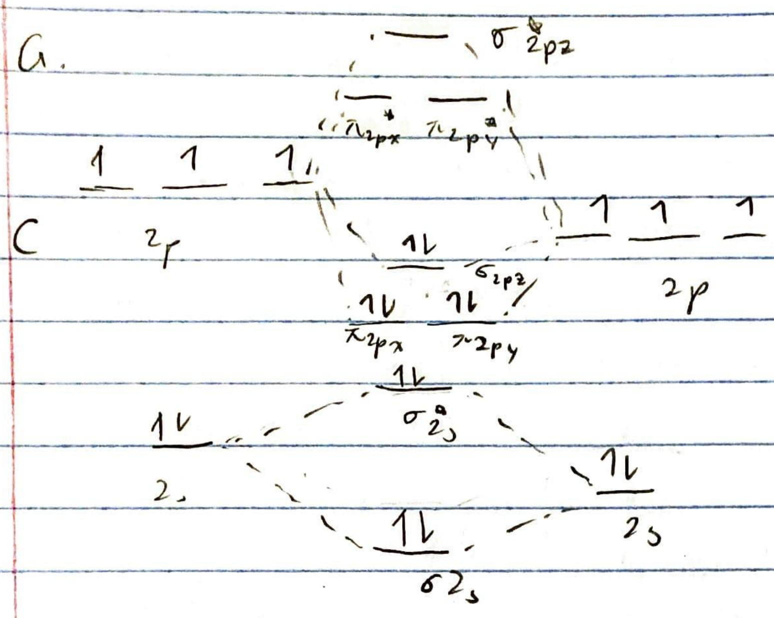
\+ **7 pts** Partial credit for part a setup and correct limiting reactant (O2)

\+ **3 pts** Partial credit for part b setup

\+ **5 pts** Correct amount of NH3 left 3.23g

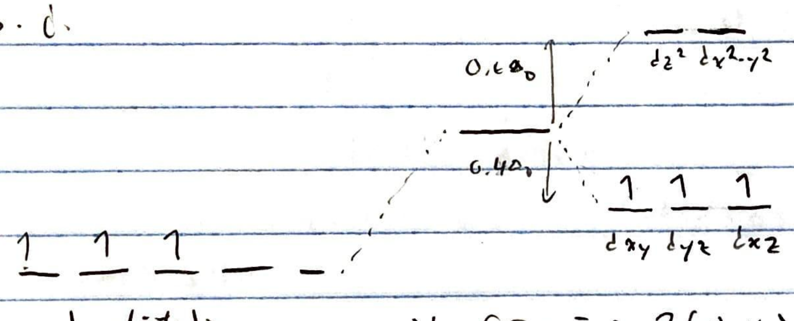
\+ **5 pts** Correct amount of C3H6 left 617g

1\. a.



The valence electron configuration is $(\sigma_{2s})^2(\sigma^*_{2s})^2(\pi_{2p})^4(\sigma_{2pz})^2$

b. i.



CN has -1 charge, so Cr has +3 charge

Cr : $[Ar]\ 4s^1\ 3d^5$

Cr^{+3} : $[Ar]\ 3d^3$

ii. CFSE: $-3(0.4)\Delta_o = -1.2\Delta_o$

iii. The complex is paramagnetic, it has 3 unpaired electrons in the t_{2g} orbitals.

c. A d-d absorption transition is referring to a jump of an e^- from the t_{2g} to the e_g orbital, which would take an energy of Δ_o. We can calculate the wavelength of light for this exact energy jump.

$$\Delta_o = E = hc/\lambda$$

$$5.51\times10^{-19}\ J = 6.626\times10^{-34}\cdot 2.99\times10^{8}/\lambda$$

$$\lambda = 3.60\times10^{-7}\ m = 360.\ nm$$

As 360 nm is in the range between 100-700, we would be able to use a UV spectrometer, as this λ and any λ shorter would be able to activate the d-d transition

1 Q1 **35 / 35**

- ✓ + **2 pts** a. levels correct
- ✓ + **2 pts** a. labels correct
- ✓ + **2 pts** a. electrons correct
- ✓ + **2 pts** a. molecular electronic configuration
- ✓ + **2 pts** b. i) d-electrons all correct
- ✓ + **4 pts** b. i) splitting levels correct
- ✓ + **2 pts** b. i) labels correct
- ✓ + **4 pts** b. ii) CFSE equation correct
- ✓ + **4 pts** b. ii) CFSE = $$-1.2\Delta_0$$
- ✓ + **2 pts** b. iii) paramagnetic
- ✓ + **2 pts** b. iii) unpaired electrons
- ✓ + **3 pts** c. conclusion: Yes
- ✓ + **2 pts** c. equations correct
- ✓ + **2 pts** c. all correct
- + **0 pts** missing the problem

2\. a. $C_k H_l O_m + \_O_2 \rightarrow \_H_2O + \_CO_2$

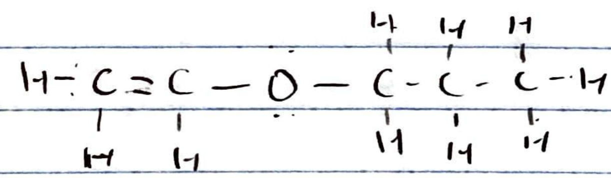
H_2O molar mass: $2 \cdot 1.008 + 15.99 \cdot 1 = 18.00$
mols H_2O produced: $5.23 / 18.00 = 0.29$ mols
CO_2 molar mass: $15.99 \times 2 + 12.011 \times 1 = 43.99$
mols CO_2 produced: $12.78 / 43.99 = 0.29$ mols
We also know $12.78 + 5.23 - 5.00 = 13.01$ g of O_2 must have been consumed due to conservation of mass. Thus:
O_2 molar mass: $15.99 \times 2 = 31.98$
mols O_2 consumed: $13.01 / 31.98 = 0.41$ mols
The ratio $0.29 : 0.41$: ~~0.71~~ simplifies to
7 : 10, so we can plug that into our equation:

$C_k H_l O_m + 10 O_2 \rightarrow 7 H_2O + 7 CO_2$

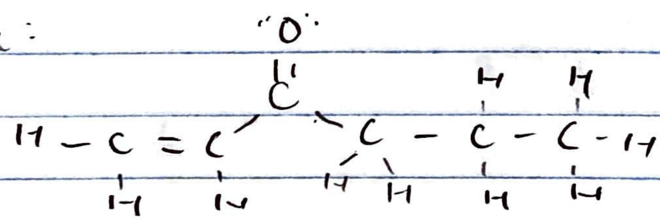
Solving, we get $k = 7$, $l = 14$, $o = 1$, so
$C_7 H_{10} O$ is the empirical formula.

b. As calculated in a, 0.41 mols of O_2 are consumed in combustion

c. Ether:

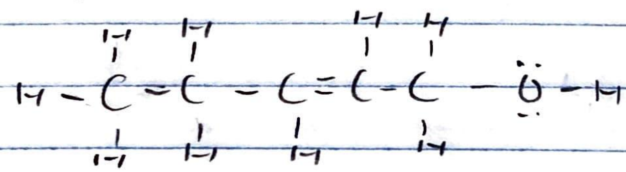


Ketone:

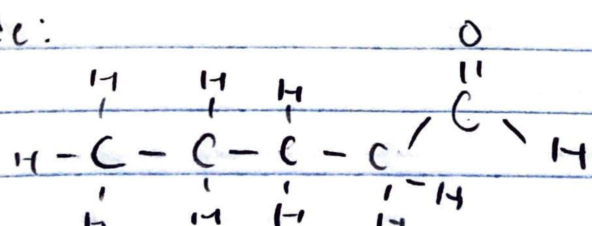


$C_5 H_{10} O$

Alcohol:



Aldehyde:



2 Q2 **23 / 32**

- \+ **12 pts** Correct a
- ✓ + **8 pts** **correct b**
- ✓ + **12 pts** **correct c**
- ✓ + **6 pts** **correct handling of H and C in a**
- \+ **4 pts** partial credit for b
- \+ **9 pts** correct handling of C and H and ratio conversion
- \+ **0 pts** incorrect
- \+ **6 pts** 2 valid structures in c
- \+ **3 pts** correct mol for oxygen
- \+ **9 pts** 3 valid structures
- **- 3 Point adjustment**

wrong ketone

3. a. We first must find the ΔE from the 2s to the 4p state. $\Delta E_n = -Z^2 \cdot (\frac{1}{n_f^2} - \frac{1}{n_i^2})$ rydbergs

$Z = 1$, $n_f = 4$, $n_i = 2$.

Thus, $\Delta E_n = -4.09 \times 10^{-19}$ J

The wavelength of a photon with energy $|\Delta E_n|$ is calculated by $E = hc/\lambda$, so $\lambda = 4.86 \times 10^{-7}$ m.

Using the Debroglie wave equation, we have $\lambda = h/p$, so $p = h/\lambda$. Thus, $p = 1.36 \times 10^{-27}$

All of this momentum is transferred to the atom, and as the atom starts from rest, it has this momentum.

Hydrogen's atomic mass is 1.008 amu, so one atom of hydrogen would have a mass of $1.008/6.022 \times 10^{23} = 1.67 \times 10^{-24}$ g

As momentum is given by $p = mv$, we can solve for the velocity using $m = 1.67 \times 10^{-27}$ kg, $p = 1.36 \times 10^{-27}$ kgm/s.

Thus, $v = 0.81$ m/s

5. We can use the Bohr model, as Li^{2+} only has one electron

$E_n = -Z^2/n^2$ rydbergs, $Z = 3$, $n = 1$. Thus, the electron has $E_n = -1.96 \times 10^{-17}$ J

To remove the electron, we would need to overcome E_n.

So, IE_3 of Li is 1.96×10^{-17} J.

3 Q3 **26 / 26**

- ✓ **+ 26 pts** **Correct A and B**
- **+ 16 pts** Correct A
- **+ 12 pts** Used wrong mass but everything else was correct.
- **+ 8 pts** Found delta E then didn't use MV=DeltaE/C
- **+ 5 pts** General idea for A
- **+ 10 pts** B is correct
- **+ 5 pts** General idea for B
- **+ 0 pts** Nothing was submitted
- **+ 8 pts** Converted wrong for B.
- **- 1 pts** Wrong sign
- **+ 0 pts** Question is wrong.
- **+ 2 pts** Wrote the correct equations to use.

4. a. i. The configuration goes $3s^2 3d^4$, when both 3p and 4s orbitals should fill before the 3d orbital. The configuration should be $[Ne] 3s^2 3p^4$

ii. This configuration denotes $[Ne] 2s^2 2p^5$, when [Ne] is shorthand for $1s^2 2s^2 2p^6$. It is not possible to have 4 electrons in 2s or 11 in 2p, this should read $[Ne] 3s^2 3p^5$

iii. This configuration skips the 2p orbital! The 2p orbital should fill before the 3s in a ground state configuration. This should read $1s^2 2s^2 2p^2$.

iv. This configuration denotes $[Kr] 4s^2 3d^1$. Like ii. [Kr] is shorthand for $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$. It is not possible to then add another $2e^-$ to 4s and $1e^-$ to 3d. This should read $[Kr] 5s^2 4d^1$

b. i. $[Ar] 3d^{10}$

ii. $[Ar] 3d^3$

iii. $[Xe] 4f^{14} 5d^8$

iv. $[Ne] 4d^{10}$

v. $[Ne] 3s^2 3p^6$

c. i. $[Kr] 4d^{10} 5s^2 5p^6$

ii. $[He] 2s^2 2p^6$

iii. $[He] 2s^2 2p^6$

iv. $[Ne] 3s^2 3p^6$

v. $[Ne] 3s^2 3p^6$

d. i. The $5p^1$ e^- is excited from the 4d orbital. Thus, the ground state config is $[Kr] 4d^7 5s^2$, so this atom would be Rh.

ii. The 4p e^- and $3p^6$ e^- are excited. The ground state config would be $1s^2 2s^2 2p^6 3s^1$, so this atom would be Na.

iii. The 5s e^- is excited. The ground state config would be $[Ar] 3d^{10} 4s^2 4p^4$, so this atom would be Se.

4 Q4 34 / 34

✓ **- 0 pts** **All correct**

(a)

- **- 2 pts** 3p fills before 4s then 3d
- **- 2 pts** $[Ne]=[He]2s^22p^6$ so needs to be 3s 3p or [He]
- **- 2 pts** 2p fills before 3s
- **- 2 pts** $[Kr]=[Ar]4s^23d^{10}4p^6$ so needs 5s 4d or [Ar]

(b)

- **- 2 pts** $Zn^{2+}= [Ar]3d^{10}$
- **- 2 pts** $Cr^{3+}= [Ar]3d^{3}$
- **- 2 pts** $Pt^{2+}= [Xe]4f^{14}5d^{8}$
- **- 2 pts** $Ag^{+}= [Kr]4d^{10}$
- **- 2 pts** $Ti^{4+}= [Ar] or [Ne]3s^23p^6$

(c)

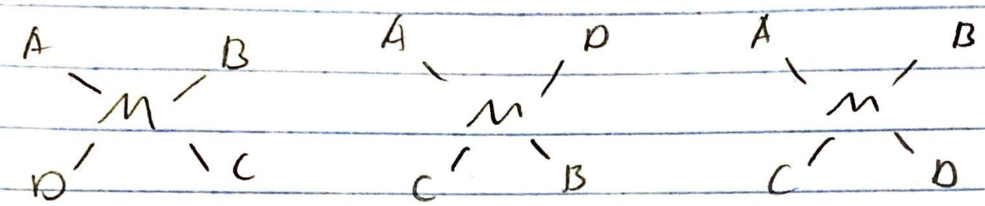
- **- 2 pts** $I^{-}= [Xe] or [Kr]5s^24d^{10}5p^6$
- **- 2 pts** $Mg^{2+}= [Ne] or [He]2s^22p^6$
- **- 2 pts** $Al^{3+}= [Ne] or [He]2s^22p^6$
- **- 2 pts** $S^{2-}= [Ar] or [Ne]3s^23p^6$
- **- 2 pts** $K^{+}= [Ar] or [Ne]3s^23p^6$

(d)

- **- 2 pts** Rh $[Kr]5s^14d^8$ or $[Kr]5s^24d^7$
- **- 2 pts** Na $1s^22s^22p^63s^1$
- **- 2 pts** Se $[Ar]3d^{10}4s^24p^4$

- **- 3 pts** (d) element not identified or configuration not given
- **- 34 pts** No answer submitted

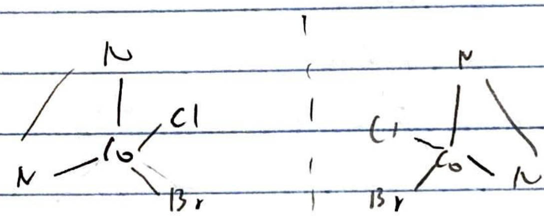
5. a.

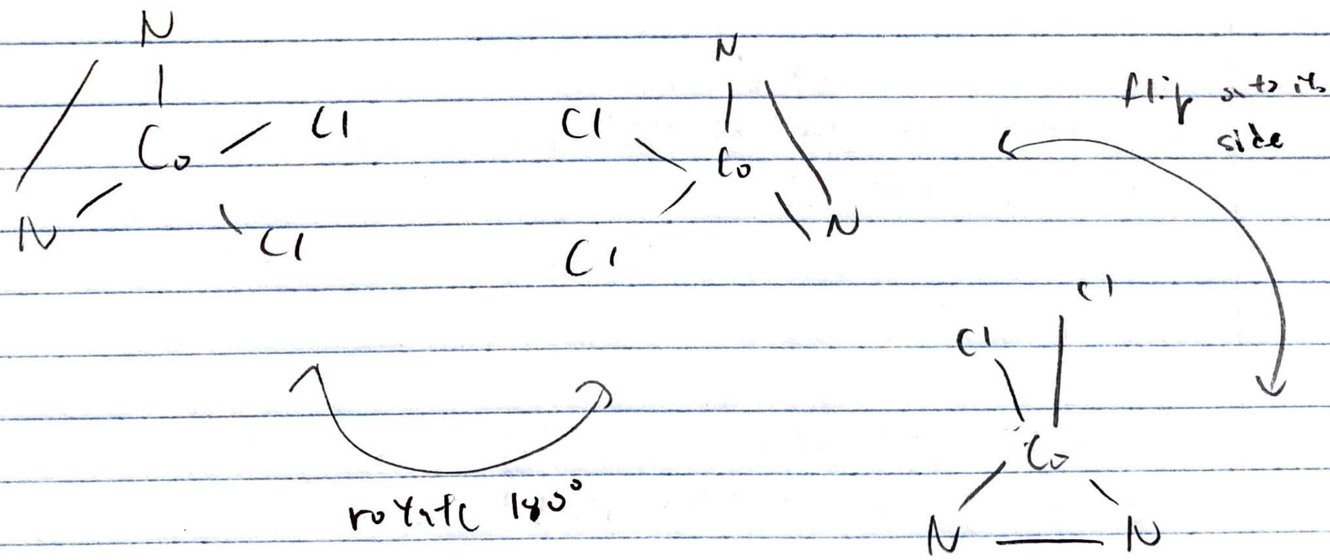


There are 3 isomers possible. None of these are enantiomers

b. i. The species doesn't have any stereoisomers. Any rearrangement or reflection of the molecule can be obtained by a rotation of the molecule.

ii. There are 2 stereoisomers for [Co(en)ClBr], they are actually enantiomers that cannot be superimposed by rotation. Thus, they are 2 distinct stereoisomers





5 Q5 **18 / 28**

✓ **+ 6 pts Part a: 3 structures correct**

+ **4 pts** Part a: 2 structures correct

+ **2 pts** Part a: 1 structure correct

✓ **+ 2 pts part a: 3 geometric isomer**

✓ **+ 2 pts part a: no enantiomers**

✓ **+ 4 pts part b i. No isomers**

✓ **+ 4 pts part b i. Explanation is correct (en and cl make binding sites equivalent, achiral, bonds have same angle, etc)**

+ **2 pts** part b i. Explanation is partially correct.

+ **4 pts** part b ii. No isomers

+ **6 pts** part b ii. Explanation is correct (en makes two binding sites equivalent, rotation will transform the structure, etc)

+ **3 pts** part b ii. Explanation is partially correct

+ **0 pts** incorrect

6. a. First lets balance the equation:

$$2C_3H_6 + 2NH_3 + 3O_2 \rightarrow 2C_3H_3N + 6H_2O$$

Molar mass of C_3H_6: $12.011 \times 3 + 1.008 \times 6 = 42.08$
mols of C_3H_6 = $5000 / 42.08 = 119$ mol
Molar mass of NH_3: $14.007 + 1.008 \times 3 = 17.03$
mols of NH_3 = $5000 / 17.03 = 294$ mol
Molar mass of O_2: $15.94 \times 2 = 31.48$
mols of O_2 = $5000 / 31.48 = 156$ mol

O_2 is the limiting reactant because 3 mols of O_2 are use for every 2 of C_3H_6. Also, 2 mols of C_3H_3N is produced for every 3 mols of O_2.

Thus, mols of C_3H_3N produced = $156 \times 2/3 = 104$ mol
Molar mass of C_3H_3N $3 \times 12.011 + 1.008 \times 3 + 14.007 = 53.06$
So, grams of C_3H_3N produced: $104 \times 53.06 = 5520$ grams

b. C_3H_6 and NH_3 remain unreacted, as they were not the limiting reactant. As 104 mol of C_3H_3N were produced, and C_3H_6 and NH_3 have a 1:1 ratio with C_3H_3N, then 104 mol of both were consumed.

Thus:

grams of C_3H_6 left over: $(119 - 104) \cdot 42.08 = 631$ g
grams of NH_3 left over: $(294 - 104) \cdot 17.03 = 3240$ g

6 Q6 **20 / 20**

- ✓ **+ 10 pts** **Part a correct 5.53kg or 5530g**
- ✓ **+ 10 pts** **Part b correct 3.23kg NH3 and 617g of C3H6 left**
- **+ 5 pts** Partial credit for part a setup
- **+ 7 pts** Partial credit for part a setup and correct limiting reactant (O2)
- **+ 3 pts** Partial credit for part b setup
- **+ 5 pts** Correct amount of NH3 left 3.23g
- **+ 5 pts** Correct amount of C3H6 left 617g
- **+ 0 pts** Graded