Solutions FORM 11

Problem 1.

(1) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g$

(2) $4NH_3(g) + O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$

(3) $2NO(g) + O_2g \rightarrow 2NO_2(g)$

(4) $3NO_2(g) + H_2O \rightarrow 2HNO_3(aq) + NO(g)$

(5) $NH_3(g) + H_2O(l) \rightarrow NH_4OH(aq)$

(6) $NH_4OH(aq) + HNO_3(aq) \rightarrow NH_4NO_3(aq)$

(7) $HNO_3(aq) + KOH(aq) \rightarrow KNO_3(aq) + H_2O(l)$ 1 point/equation

Problem 2.

a. burning reaction: glucose: $C_6H_{12}O_6 + 6O_2(g) \rightarrow 6CO_2 + 6H_2O$ 1 point

$m(O_2)_{spent}$ = 68 kg x 24.5 ml/(kg·min) x 16.5 min = 27490 ml

$n(O_2)_{spent}$ = 27.49 L x 101,3 kPa/(8.31 J/(K·mol) x 273.2 K) = 1.23 mol

$n(glucose)_{needed}$ = 1/6 x 1,23 mol = 0.205 mol; $ENERGY_{used}$ = 2803 kJ/mol x 0.205 mol = 575 kJ 2 points

b. $ENERGY_{needed}$ = 68 kg x 0.450 kJ/(kg·min) = 30.6 kJ/min

t_{needed} = 38 kJ/g /(30.6 kJ/min) x 125 g = 155 min = 2 h 35 min 2 points

c. burning reaction fat: $C_{57}H_{110}O_6 + 81.5O_2 \rightarrow 57CO_2 + 55H_2O$ 1 points

if 2803 kJ of energy is get from glucose 6 moles of oxygen is needed, if from fat:

$m(fat)_{needed}$ = 2803 kJ/38 kJ/g = 73.76 g => $n(rasva)_{needed}$ = 73.76 g/ 891.5 g/mol = 0.0827 mol

$n(O_2)_{needed}$ = 0.0827 mol x 81.5 mol = 6.74 mol

0.74 mol/6.00 mol x 100% = 12.3 % more oxygen is needed when fat is burnig 3 points

Problem 3.

a. If we take 100 g of compound the

n(Y) = 13.4 g/ 88.9 g/mol = 0.151 mol ; n(Ba) = (41.2 g/ 137.33 g/mol) = 0.300 mol

n(Cu) = 28.6 g/63.55 g/mol = 0.450 mol

m(O) = (100-13.4-41.2-28.6)g = 16.8 g; n(O) = 16.8 g/16.0 g/mol = 1.050 mol

n(Y):n(Ba):n(Cu):n(O) = 0.151:0.300:0.450:1.050 ≈ 1:2:3:7

Empirical formula: $YBa_2Cu_3O_7$ 2 points

b.If we mark the oxidation number of copper with a we get because compound is electrically neutral

3 + 2·2 + 3·x – 7·2 = 0 => x = 7/3

So the average oxidation number for copper in the compound is 7/3 2 points

c.In the reduction with hydrogen gas only the number of oxygen atom changes, so we can mark their number with a. So the empirical formula of the new electrically neutral compound is $YBa_2Cu_3O_a$

3 + 2·2 + 3·2 – a·2 = 0 => a = 6.5 => Empirical formula: $YBa_2Cu_3O6_{6.5}$; $M(YBa_2Cu_3O_{6.5})$ 658.2 g/mol

Mass% of oxygen = 6.5x16.0 g/mol / 658.2 g/mol x 100 % = 15.8 % 3 points

d. $M(YBa_2Cu_3O_7)$ 666.2 g/mol

$n(YBa_2Cu_3O_7) = 84.2\times10^{-3}$g/ 666.2 g/mol $=1.264\times10^{-4}$ mol

in the reduction reaction one mole of $YBa_2Cu_3O_{6.5}$ gives one mole of $YBa_2Cu_3O_7$ so

$n(YBa_2Cu_3O_{6.5}) = 1.264\times10^{-4}$ mol

$m(YBa_2Cu_3O_{6.5}) = 1.264\times10^{-4}$ mol x 658.2 g/mol = 0.0832 g = 83.2 mg 1 point

Problem 4.

a. n(**B**) = 0.211 L x 101.3 kPa/(8.314J/(K·mol) x 298.2 K) = $8.63\cdot10^{-3}$ mol

M(**B**) = 0.38 g/ 8.63·10 mol ≈ 44 g/mol => **B** = CO_2 3 points

A = $FeCO_3$ B = CO_2 C = $FeSO_4$ D = $Fe(OH)_3$ E = $FeCl_3$

Reactions: $3H_3O^+(aq) + SO_4^{2-}(aq) + FeCO_3(s) \rightarrow Fe^{2+}(aq) + SO_4^{2-}(aq) + 3H_2O + CO_2(g)$

$5Fe^{2+} + MnO_4^-(aq) + 8H_3O^+(aq) \rightarrow 5 Fe^{3+}(aq) + Mn^{2+}(aq) + 12 H_2O$ 1 point

$Fe^{2+}(aq) + H_2O_2(aq) 2H_3O^+ \rightarrow 2 Fe^{3+}(aq) + 4H_2O$

$Fe^{3+}(aq) + 3OH^-(aq) \rightarrow Fe(OH)_3(s)\downarrow$

$Fe(OH)_3(s) + 3H_3O^+(aq) + 3Cl^-(aq) \rightarrow FeCl_3(aq) + 6H_2O$

$FeCl_3(aq) + 3SCN^-(aq) \rightarrow Fe(SCN)_3(aq) + 3Cl^-(aq)$ other reactions and compounds 0.6 points/

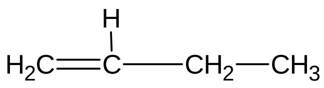
b. Weighed portion: $n(FeCO_3)$ = 1.0 g/ 115.86 g/mol = $8.631\cdot10^{-3}$ mol

Titration: $½\cdot n(Fe^{2+}) = 5\cdot n(MnO_4^-)$

$n(Fe^{2+})$ = 2 x 5 x 0.0200 mol/L x $43.15\cdot10^{-3}$L = $8.631\cdot10^{-3}$ mol

So total amount reacted 3 points

Problem 5.



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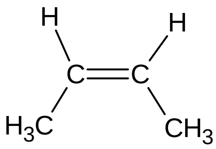

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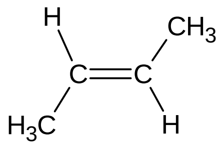

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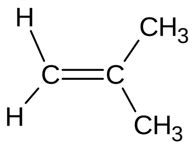

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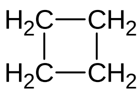

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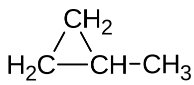

6

i   structures 1, 2, 3 and 4 are accebtable   **A, B, C, D**, so 5 and 6 are **E** and **F**
ii   structures 2 and 3 are accebtable **B** and **C**
iii 1, 2 and 3 accebtable **A**, **B** and **C**   so 4 = <u>**D** = 2-methyl propene</u>
iv   6 is slightly and 5 is nonpolar => 6 = **E** = methyl cyclopropane
and 5 = **F** = cyclobutane
v   2 is polar and 3 is nonpolar   2 = **C** = cis-2-butene
and 3 = **B =** trans-2-butene   and **A** = 1-butene

If only the six structures and names are given then 4 points (each missing -1 point)
If all compounds are identified then 5 points more altogether 9 points
If only four of the six are identified then -2 points altogether 7 points
if only three of the six are identified then – 3 points altogether 6 points
if only two of the six are identified then -4 points altogether 5 points