CHEM 1101C – Make-up and PMC exam

print your NAME: Soln's

Calculators allowed. 80 minutes.

Student number:________________________

Data/Equations:

$E = h\nu$

$E = hc/\lambda$

$E = R_H\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right)$

$h = 6.626 \times 10^{-34}$ J·s

$c = 3.00 \times 10^{8}$ m/s

$R_H = 2.18 \times 10^{-18}$ J

Avogadro's number: 6.02×10^{23} mol^{-1}.

The periodic table
www.webelements.com

Key: Element Name / **Atomic number** / **Symbol** / Atomic weight (mean relative mass)

1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Hydrogen 1 **H** 1.008																		Helium 2 **He** 4.0026
Lithium 3 **Li** 6.94	Beryllium 4 **Be** 9.0122												Boron 5 **B** 10.81	Carbon 6 **C** 12.011	Nitrogen 7 **N** 14.007	Oxygen 8 **O** 15.999	Fluorine 9 **F** 18.998	Neon 10 **Ne** 20.180
Sodium 11 **Na** 22.990	Magnesium 12 **Mg** 24.305												Aluminium 13 **Al** 26.982	Silicon 14 **Si** 28.085	Phosphorus 15 **P** 30.974	Sulfur 16 **S** 32.06	Chlorine 17 **Cl** 35.45	Argon 18 **Ar** 39.948
Potassium 19 **K** 39.098	Calcium 20 **Ca** 40.078(4)		Scandium 21 **Sc** 44.956	Titanium 22 **Ti** 47.867	Vanadium 23 **V** 50.942	Chromium 24 **Cr** 51.996	Manganese 25 **Mn** 54.938	Iron 26 **Fe** 55.845(2)	Cobalt 27 **Co** 58.933	Nickel 28 **Ni** 58.693	Copper 29 **Cu** 63.546(3)	Zinc 30 **Zn** 65.38(2)	Gallium 31 **Ga** 69.723	Germanium 32 **Ge** 72.63	Arsenic 33 **As** 74.922	Selenium 34 **Se** 78.96(3)	Bromine 35 **Br** 79.904	Krypton 36 **Kr** 83.798(2)
Rubidium 37 **Rb** 85.468	Strontium 38 **Sr** 87.62		Yttrium 39 **Y** 88.906	Zirconium 40 **Zr** 91.224(2)	Niobium 41 **Nb** 92.906(2)	Molybdenum 42 **Mo** 95.96(2)	Technetium 43 **Tc** [97.91]	Ruthenium 44 **Ru** 101.07(2)	Rhodium 45 **Rh** 102.91	Palladium 46 **Pd** 106.42	Silver 47 **Ag** 107.87	Cadmium 48 **Cd** 112.41	Indium 49 **In** 114.82	Tin 50 **Sn** 118.71	Antimony 51 **Sb** 121.76	Tellurium 52 **Te** 127.60(3)	Iodine 53 **I** 126.90	Xenon 54 **Xe** 131.29
Caesium 55 **Cs** 132.91	Barium 56 **Ba** 137.33	57-70 *	Lutetium 71 **Lu** 174.97	Hafnium 72 **Hf** 178.49(2)	Tantalum 73 **Ta** 180.95	Tungsten 74 **W** 183.84	Rhenium 75 **Re** 186.21	Osmium 76 **Os** 190.23(2)	Iridium 77 **Ir** 192.22	Platinum 78 **Pt** 195.08	Gold 79 **Au** 196.97	Mercury 80 **Hg** 200.59	Thallium 81 **Tl** 204.38	Lead 82 **Pb** 207.2	Bismuth 83 **Bi** 208.98	Polonium 84 **Po** [208.98]	Astatine 85 **At** [209.99]	Radon 86 **Rn** [222.02]
Francium 87 **Fr** [223.02]	Radium 88 **Ra** [226.03]	89-102 **	Lawrencium 103 **Lr** [262.11]	Rutherfordium 104 **Rf** [265.12]	Dubnium 105 **Db** [268.13]	Seaborgium 106 **Sg** [271.13]	Bohrium 107 **Bh** [270]	Hassium 108 **Hs** [277.15]	Meitnerium 109 **Mt** [276.15]	Darmstadtium 110 **Ds** [281.16]	Roentgenium 111 **Rg** [280.16]	Copernicium 112 **Cn** [285.17]	Ununtrium 113 **Uut** [284.18]	Flerovium 114 **Fl** [289.19]	Ununpentium 115 **Uup** [288.19]	Livermorium 116 **Lv** [293]	Ununseptium 117 **Uus** [294]	Ununoctium 118 **Uuo** [294]

*lanthanoids	Lanthanum 57 **La** 138.91	Cerium 58 **Ce** 140.12	Praseodymium 59 **Pr** 140.91	Neodymium 60 **Nd** 144.24	Promethium 61 **Pm** [144.91]	Samarium 62 **Sm** 150.36(2)	Europium 63 **Eu** 151.96	Gadolinium 64 **Gd** 157.25(3)	Terbium 65 **Tb** 158.93	Dysprosium 66 **Dy** 162.50	Holmium 67 **Ho** 164.93	Erbium 68 **Er** 167.26	Thulium 69 **Tm** 168.93	Ytterbium 70 **Yb** 173.05
**actinoids	Actinium 89 **Ac** [227.03]	Thorium 90 **Th** 232.04	Protactinium 91 **Pa** 231.04	Uranium 92 **U** 238.03	Neptunium 93 **Np** [237.05]	Plutonium 94 **Pu** [244.06]	Americium 95 **Am** [243.06]	Curium 96 **Cm** [247.07]	Berkelium 97 **Bk** [247.07]	Californium 98 **Cf** [251.08]	Einsteinium 99 **Es** [252.08]	Fermium 100 **Fm** [257.10]	Mendelevium 101 **Md** [258.10]	Nobelium 102 **No** [259.10]

Symbols and names: the symbols and names of the elements, and their spellings are those recommended by the International Union of Pure and Applied Chemistry (IUPAC - http://www.iupac.org/). Names have yet to be proposed for elements 113, 115, 117, and 118 and so those used here are IUPAC's temporary systematic names. In some countries, the spellings **aluminum**, **cesium**, and **sulphur** are usual.
Group labels: the numeric system (1–18) used here is the current IUPAC convention.
Atomic weights (mean relative masses): these are the IUPAC 2009 values and given to 5 significant figures. The last significant figure of each value is considered reliable to ±1 except where a larger uncertainty is given in parentheses. Representative values for those elements having an atomic weight interval are given (H, Li, B, C, N, O, Si, S, Cl, Tl). Elements for which the atomic weight is given within [brackets] have no stable nuclides and are represented by the element's longest lived isotope reported in the IUPAC 2009 values.

-1 per error
• missing / wrong roman numeral
• roman numeral where none belong
• wrong word/name

1a. Give the IUPAC (systematic) name of the following: (aluminium)

3 $MnCl_3$: Manganese (III) chloride — $AlCl_3$: aluminum chloride 3

3 $MnCO_3$: Manganese (II) carbonate — SO_3: sulfur trioxide 3

1b. Give the chemical formula for the following:

2 Manganese(II) nitrate: $Mn(NO_3)_2$ — 2 Manganese(II) sulfate: $MnSO_4$

2 Aluminum sulfate: $Al_2(SO_4)_3$ — 2 Aluminum sulfide: Al_2S_3

-1 per error (formula molecular ion: 1) wrong ratio: -1

no lower than 0 on anyone.

/20

2. Write the ground state electron configuration of $_{76}Os$. Use the arrow notation to show all electrons.

Os: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^6$

or $[Xe]\ 6s^2 4f^{14} 5d^6$

-10 if shown full

$5d^6$	1↓ 1 1 1 1
$4f^{14}$	1↓ 1↓ 1↓ 1↓ 1↓ 1↓ 1↓
$6s^2$	1↓
$5p^6$	1↓ 1↓ 1↓
$4d^{10}$	1↓ 1↓ 1↓ 1↓ 1↓
$5s^2$	1↓
$4p^6$	1↓ 1↓ 1↓
$3d^{10}$	1↓ 1↓ 1↓ 1↓ 1↓
$4s^2$	1↓
$3p^6$	1↓ 1↓ 1↓
$3s^2$	1↓
$2p^6$	1↓ 1↓ 1↓
$2s^2$	1↓
$1s^2$	1↓

-10 if all paired 1↓ 1↓ 1↓ _ _

-5 for each orbital in wrong energy order if only some are wrong (ie ... $4s^2$ $3d^{10}$ $3p^6$ $3s^2$ ...) would be -5. It's one error that flipped the two.

for arrow notation they must be in order of increasing energy.

BUT -15 if all orbitals are in numerical order

/20

−10 if they don't try to balance ie if they treat the equation as 1:1 → 1:1

3. Given the chemical reaction (as yet unbalanced) $NH_3 + IBr \rightarrow NI_3 + NH_4Br$

a) Assuming a 100% yield, what mass of NI_3 can be formed if 200.0g of NH_3 is mixed with 1800.0g of IBr, and they are allowed to react?

$4\,NH_3 + 3\,IBr \rightarrow NI_3 + 3\,NH_4Br$

5 marks if balanced correctly.
−2 per element that's wrong (max −5)

−2 per calculation error.

$\frac{200.0g\ NH_3}{17.031 g/mol} = 11.74329$ moles NH_3

−3 if molar mass wrong (per molar mass so −6 if both wrong)

$\frac{1800.0g\ IBr}{206.804 g/mol} = 8.70389$ moles IBr

−5 if they multiply by molar mass

−10 if not converted to moles ie. if they take a ratio based on mass.

don't have enough IBr. ∴ LIMITING.

−2 per calculation error.

LIM: $\frac{4\ NH_3}{11.74329\ NH_3}$ needs $\frac{3\ IBr}{x}$; x = 8.80746 moles IBr Needed

−5 if ratio is wrong for bal eqn (ie if they do x 4/3 instead of x 3/4)
−10 if they don't check for limiting reagent somehow.

−2 per calc. error.

Product: $\frac{3\ IBr}{8.70389\ IBr} \rightarrow \frac{1\ NI_3}{x}$ x = 2.901297 moles NI_3

−5 if ratio doesn't match their equation (3:1 if balanced correctly) (eg if they do X3 instead of ÷3)

Mass: 2.901297 mol NI_3 * 394.707g/mol = 1145.1 g (1145g) OR 1.145 kg

−3 if wrong molar mass

−5 if they divide by molar mass.

a) /20

b) What mass of NI_3 can be formed with these masses of starting material if the yield is only 81.8%?

1145.1g * $\frac{81.8}{100}$ = 936.7g or 0.9367 kg

Give full 5 marks as long as this is 81.8% of their answer

−4 if they divide by 0.818 (ie if mass in b larger than mass in a)
− 2 if calculation error.

NOTE in part a. If they make an error balancing, but their work is consistent with their balanced equation, they lose balancing marks but get full marks for the rest as long as it's consistent & the technique is correct.

b) /5

/25

NAME:______________ Student number:______________

4. An electron makes a transition in a hydrogen atom and ***emits*** a photon of wavelength 656nm. If the final state is the n=2 state, determine the state that the electron was in initially.

$\lambda = 656$ nm

$E = \frac{hc}{\lambda} = \frac{(6.626\times10^{-34} J.s)(3.00\times10^{8} m/s)}{656\times10^{-9} m}$

−5 if NOT converted to meters at some step

$= 3.030182\times10^{-19}$ J emitted

$E = R_H(1/n_i^2 - 1/n_f^2)$ $\therefore -3.030182\times10^{-19}$ J

$-3.030182\times10^{-19} J = 2.18\times10^{-18} J (1/n_i^2 - 1/2^2)$

$-0.138999 = 1/n_i^2 - 0.25$

$0.111000 = 1/n_i^2$

$3 = n_i$

give FULL marks if correct.

−3 if "9" (forgot √)

−5 if E is not entered as a -ve value.

−5 if answer not given as an INTEGER.

/20

5. **Dimensional analysis:** The heat of combustion of methane, CH_4 (natural gas; we heat our homes with it) has been found to be 889 kJ/mol. Given that one British Thermal Unit (BTU) is equal to 1055 J, and using the periodic table given, determine what the heat of combustion is in units of BTU/kg (British Thermal Units per kilogram).

NOTE They can do the conversions in either order!

10 marks for each conversion eg kJ → BTU /mol → /kg

Energy: $889 kJ \times \frac{1 BTU}{1.055 kJ} = 842.654$ BTU for 1 mol

−7 if upside down

−2 for calc error

−5 if not converted to kJ * kJ or J * J.

/10

Mass: 1 mol CH_4 = 16.043 g

so we know 842.654 BTU are produced by 16.043 g

we want to know x — 1000 g ("1 kg")

−7 if molar mass not used.

−2 calc. error.

$x = 52\,525$ BTU per kg

−5 if reversed (g × 1000/16.043)

/10

Some marking notes on next page.

/20

They can do either way

Q5 NOTE if they do it in reverse order:

889 kJ when 1 mol is burned

Mass

-2 calc error.

$\Rightarrow \frac{889 \text{ kJ}}{x}$ when ✗ $\frac{16.043 \text{ g}}{1000 \text{ g}}$ are burned -5 if reversed (eg $\frac{1000}{16.043}$)

-7 if molar mass not used.

$x = 55\,413.576$ kJ per kg

/10

and 1 BTU = 1.055 kJ

-5 if not either both in kJ or both in J.

Energy

$\therefore \quad 55\,413.576 \frac{\text{kJ}}{\text{kg}} * \frac{1 \text{ BTU}}{1.055 \text{ kJ}}$

-7 if upside down $\left(\frac{1.055}{1}\right)$

-2 calc error.

$= 52\,525$ BTU/kg

/10

OR They can do it all in one "chain"

/20

-7 if upside down

-5 if upside down

$889 \frac{\text{kJ}}{\text{mol}} * \frac{1 \text{ BTU}}{1.055 \text{ kJ}} * \frac{1000 \text{ g/kg}}{16.043 \text{ g/mol}}$ -5 if no 1000g/kg

-7 if no molar mass

$= 52\,525$ BTU/kg

-2 per calculation error

Whether done in two steps or in one step

FULL MARKS IF CORRECT.