NAME:

STUDENT ID Nº

CHEM 114: Mid-course TEST
MONDAY 4th MAY 2009 7.00-9.00pm
Answer ALL QUESTIONS

TIME MANAGEMENT:
This examination is marked out of 120. An approximate marking scheme is provided to help you allocate your time effectively. You are encouraged to spend approximately 1 minute per mark allocated.

ANSWERS:
*Fill in your answers in the spaces provided. If you need more space (*e.g. *for calculation workings) please use the blank paper on the back of the preceding page*

PERIODIC TABLE*:*
A Periodic Table is included on a separate sheet. You are encouraged to use it.

Please leave blank. For Staff use only

Q1 /34	Q2 /23	Q3 /4	Q4 /20	Q5 /12	Q6 /19	Q7 /8	Total/120

QUESTION 1 ***[34 marks total]***

Lithium, Li, is widely distributed on the earth and is produced industrially from rocks in the Andes. It occurs naturally as a mixture of two isotopes: lithium-6 and lithium-7. Lithium salts are used as pharmaceuticals in the treatment of mental health problems; other lithium salts are used in rechargeable lithium ion batteries.

Answer the following questions **(a)** – **(h)** about lithium.

(a) Lithium-6 and lithium-7 differ in their number of

Protons Electrons Neutrons

Circle the correct answer(s). *[1 mark]*

(b) The isotopic composition of natural samples of lithium vary. A groundwater sample of lithium is found to contain 4.50% lithium-6 and 95.50% lithium-7. The relative atomic mass of lithium-6 is 6.015, while that of lithium-7 is 7.016. Calculate the atomic weight of lithium in this sample. Show the details of your calculation. *[4 marks]*

(c) Lithium is never found on earth as the element, instead it is always found in chemical compounds. Briefly explain why. *[3 marks]*

(c) Lithium (Li) reacts with fluorine (F_2) to produce lithium fluoride. Write out the electronic configurations for these two elements. *[4 marks]*

Li

F

(d) Write out a balanced equation for the formation of lithium fluoride from the *elements*. Include symbols for the physical state of reactants and product. *[3 marks]*

(e) Lithium fluoride, prepared from isotopically pure lithium-7, is used in certain types of nuclear reactor. How many moles of metallic lithium-7 are needed to prepare a 3.250 kg sample of lithium fluoride? Show the details of your calculation. *[4 marks]*

(f) How many moles of fluorine are needed to prepare a 3.250 kg sample of lithium fluoride containing only lithium-7? Explain your answer. *[2 marks]*

(g) Lithium is a solid which melts at 181^{o}C, whereas fluorine is a gas which boils at -188^{o}C. Explain the reasons for these different material properties in terms of the **bonding** properties of elemental lithium and fluorine. *[8 marks]*

(h) Predict the nature of **bonding** in a sample of lithium fluoride. Explain your reasoning. Use this information to predict some of the **material** properties (physical properties) of lithium fluoride, explaining your reasoning. *[5 marks]*

QUESTION 2 ***[23 marks total]***

The following table lists some enthalpy changes for processes associated with the formation of magnesium fluoride from magnesium and fluorine.

TABLE

(**A**) Enthalpy change for atomisation of magnesium $Mg(s) \rightarrow Mg(g)$, $\Delta H = +147$ kJ mol^{-1}

(**B**) Enthalpy change for atomisation of fluorine $\frac{1}{2} F_2(g) \rightarrow F(g)$, $\Delta H = +79$ kJ mol^{-1}

(**C**) First ionization energy of magnesium $Mg(g) \rightarrow Mg^+(g) + e^-$, $\Delta H = +744$ kJ mol^{-1}

(**D**) Second ionization energy of magnesium $Mg^+(g) \rightarrow Mg^{2+}(g) + e^-$, $\Delta H = +1457$ kJ mol^{-1}

(**E**) First electron affinity of fluorine $F(g) + e^- \rightarrow F^-(g)$, $\Delta H = -328$ kJ mol^{-1}

(**F**) Lattice enthalpy of MgF_2 $Mg^{2+}(g) + 2\ F^-(g) \rightarrow MgF_2(s)$ $\Delta H = -2957$ kJ mol^{-1}

(a) For the six processes (**A**-**F**) listed in the **TABLE** briefly explain the reasons for the value (the sign and the magnitude) of each enthalpy change. ***[18 marks]***

(b) Use the values given in the **TABLE** to calculate the enthalpy change for the formation of MgF_2. Show details of your calculation and briefly explain your reasoning.

[5 marks]

QUESTION 3 ***[4 marks total]***

The lattice enthalpy for MgO (-4050 kJ/mol) is about four times more negative than the value for NaF (-926 kJ/mol). Explain why this makes sense. *[4 marks]*

QUESTION 4 ***[20 marks total]***

The following table gives the boiling points of four organic compounds.
Answer parts **(a)-(e)** using these data.

TABLE: Boiling points of some organic compounds

	Compound	*Formula*	*Molecular mass*	*Boiling point (^oC)*
(i)	Ethane	CH_3CH_3	30	-89
(ii)	Hexafluoroethane	CF_3CF_3	138	-78
(iii)	Trifluoroethane	CF_3CH_3	84	-48
(iv)	Trifluoroethanol	CF_3CH_2OH	100	+78

(a) What is the orientation of the two bonds around the oxygen atom in trifluoroethanol? (circle the correct answer) *[1 mark]*

Square Linear Bent Tetrahedral

(b) Briefly explain why the bonds around this oxygen atom adopt this shape.*[3 marks]*

(c) Identify the compound in the **TABLE** that can form hydrogen-bonds. How does hydrogen-bonding affect its physical properties? Briefly explain your reasoning. *[5 marks]*

(d) Identify the compound in the **TABLE** that possesses a permanent dipole, but which is incapable of hydrogen-bonding. Briefly explain your reasoning. *[3 marks]*

(e) What are the most important intermolecular forces of attraction in ethane? Briefly explain your reasoning. *[4 marks]*

(f) Briefly explain why trifluoroethane has a higher boiling point than hexafluoroethane. *[4 marks]*

QUESTION 5 ***[12 marks total]***

State whether the sign of the entropy change expected for each of the following processes will be positive or negative and briefly explain your predictions.

(a) $N_2H_4(l) \rightarrow N_2(g) + 2H_2(g)$ *[4 marks]*

(b) $2C(s) + O_2(g) \rightarrow 2CO(g)$ *[4 marks]*

(c) $C(s) + O_2(g) \rightarrow CO_2(g)$ *[4 marks]*

QUESTION 6 ***[19 marks total]***

The formation of NH_3 from nitrogen and hydrogen is a very important industrial reaction. The following data will be useful in answering this question:

Species	ΔH_f^o ($Jmol^{-1}$)	S^o ($JK^{-1}mol^{-1}$)
$N_2(g)$	0	192
$H_2(g)$	0	131
$NH_3(g)$	-46,000	193

(a) Write a balanced equation for the reaction. *[3 marks]*

(b) Why are the first two ΔH_f^o values zero? *[2 marks]*

(c) Use the values in the table to calculate ΔS for the reaction at 298 K and explain the implications of that value. *[5 marks]*

(d) A process will be spontaneous if: $\Delta S_{sys} - \Delta H_{sys}/T > 0$
Is this the case for this reaction at 298 K?

YES NO

Circle the correct answer. *[1 mark]*

(e) Do you think that this will still be the case at very high temperature? Explain your reasoning. *[5 marks]*

(f) If a reaction is less favourable at high temperature, why might you still want to heat the reaction? *[3 marks]*

QUESTION 7 ***[8 marks total]***

Explain how you would determine if a reaction was first or second order in a reactant. *[8 marks]*

END OF TEST