Name: ____________________ Student number: ______________

Chemistry 1A03 **Final Exam – Version 1** **December, 2007**

Instructor: Drs. P. Britz-McKibbin, G. Goward, P. Lock

MCMASTER UNIVERSITY FINAL EXAMINATION Duration: 3 hours

This exam contains 32 numbered pages. There are **35** multiple-choice questions appearing on pages numbered 3 to 26. Pages 27-30 are extra space for rough work. Page 31 includes some useful data and equations, and there is a periodic table on page 32. You may tear off the last pages to view the periodic table and the data provided.

These question sheets must be returned with your answer sheet. **However, no work written on the question sheets will be marked**. **You must enter your full name and student number on this question sheet, as well as on the answer sheet**. Your invigilator will be checking your student card for identification.
You are responsible for ensuring that your copy of the question paper is complete. Bring any discrepancy to the attention of your invigilator.

Questions 1 to 24 are each worth 2 marks, questions 25 – 35 are each worth 3 marks; the total marks available are 81. There is **no** additional penalty for incorrect answers.
BE SURE TO ENTER THE CORRECT VERSION OF YOUR TEST (shown near the top of page 1), IN THE CORRECT COLUMN ON THE ANSWER SHEET.

ANSWER ALL QUESTIONS ON THE ANSWER SHEET, IN PENCIL.
Instructions for entering multiple-choice answers are given on page 2.
SELECT ONE AND ONLY ONE ANSWER FOR EACH QUESTION from the answers **(A)** through **(E).**

Academic dishonesty may include, among other actions, communication of any kind (verbal, visual, *etc*.) between students, sharing of materials between students, copying or looking at other students' work. If you have a problem please ask the invigilator to deal with it for you. Do not make contact with other students directly. Try to keep your eyes on your own paper – looking around the room may be interpreted as an attempt to copy.

Only Casio FX 991 electronic calculators may be used; but they must NOT be transferred between students. Use of periodic tables or any aids, other than those provided, is not allowed.

See page 2 of the exam for instructions. Questions 1 – 24 are worth 2 marks each.

1. ΔH (enthalpy) and ΔU (internal energy) are only equal to each other when:

(A) Pressure is constant.

(B) No work is done.

(C) Reaction occurs in the gas phase.

(D) ΔS is equal to zero.

(E) They are never equal.

2. The heat of reaction for $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$ is determined using an ice calorimeter similar to that seen in experiment # 5. The experimental result differed from the actual value by 20%. Which of the following **experimental errors** would have the **greatest influence** on the result?

(A) ΔV, which was in the range of 0.5 mL, was measured with a pipette that was only calibrated to the nearest .01 of a mL.

(B) The top of the calorimeter was not insulated from the surroundings with a secondary layer of ice.

(C) HCl, while added at 0ºC, was accidentally in 5 times mole excess to Mg.

(D) The H_2 gas formed during the reaction was allowed to escape the calorimeter.

(E) The heat capacity of the resulting $MgCl_2$ solution was not factored into the calculations.

 Continued on next page

3. KHP is a monoprotic acid with a molecular formula of $KHC_8H_4O_4$ (MW = 204.2215 g/mol). In order to titrate a sample of KHP, a stock solution of NaOH was standardized by titration with 0.1453 M HCl. The end point of the HCl/NaOH titration was reached when 18.23 ml of HCl was added to 10.00 ml of NaOH. If 18.85 mL of NaOH was then required to reach an equivalence point with 1.564 g of an impure KHP sample, **what is the % composition of KHP in the impure sample**? (Assume all impurities in the KHP sample do not participate in acid/base chemistry)

(A) 12.11 %
(B) 52.18 %
(C) 71.29 %
(D) 23.19 %
(E) 65.20%

4. A mass of **8.314 g of glucose** ($C_6H_{12}O_6$) was combusted in a closed vessel containing **4.971 L** of pure oxygen at 25°C and 1.00 atm pressure. The combustion proceeded as far as possible producing only **water** and **carbon dioxide** as products. What **mass of glucose (g) remained** after the reaction was complete?

(A) 2.343 g
(B) 6.086 g
(C) 2.213 g
(D) 0.219 g
(E) 0 g

 Continued on next page

5. Nitrous oxide (N_2O) is a greenhouse gas in the atmosphere whose concentration has exponentially increased during the past 50 years because of intensive use of ammonia based fertilizers in agriculture.

Determine the **CORRECT average bond order (over <u>all</u> bonds)** and **total number of resonance structures** based on its charge-minimized Lewis structure, where formal charges are less than or equal to ±1 on each atom. (N is the central atom in the structure).

(A) Bond order: 1; Resonance structures: 1

(B) Bond order: 3; Resonance structures: 3

(C) Bond order: 1.5; Resonance structures: 1

(D) Bond order: 2.5; Resonance structures: 2

(E) Bond order: 2; Resonance structures: 2

6. Which of the following statements are **FALSE**:

(i) The hydrogen atom emits energy when its electron moves from n=1 to n = 3.

(ii) The photoelectric effect states that energy of a photon in excess to the binding energy of a substance is transferred into the kinetic energy of the emitted photoelectron.

(iii) The ionization energy for a ground state hydrogen atom is equivalent to the magnitude of the Rydberg constant, R_H.

(iv) The wavelength of a moving object is inversely proportional to its mass.

(v) Ca^{2+} is isoelectronic with O^{2-}.

(A) iii, iv

(B) ii, v

(C) i, iv

(D) ii, iii

(E) i, v

7. Stratospheric ozone plays a critical role for absorbing ionizing UV-B solar radiation from reaching the surface of the Earth. Calculate the **average bond energy (kJ/mol)** for O_3 if the **maximum wavelength** of a photon that has sufficient energy to induce the photolysis of ozone is **320. nm**.

$$O_3\,(g) \xrightarrow{\lambda < 320\ nm} O_2\,(g) + O\,(g)$$

(A) 1440 kJ/mol
(B) 189 kJ/mol
(C) 92.1 kJ/mol
(D) 0.135 kJ/mol
(E) 374 kJ/mol

8. The first step in the conversion of $SO_2(g)$ into acid rain is its oxidation to $SO_3(g)$. Consider this equilibrium, $2\,SO_2(g) + O_2(g) \rightleftharpoons 2\,SO_3(g)$, where ΔH is negative. Which of the following statements is **FALSE**?

(A) Addition of $SO_2(g)$ will cause the equilibrium to shift to the right.
(B) Decreasing the temperature will cause the equilibrium to shift to the right.
(C) Removal of $O_2(g)$ will cause K_P to decrease.
(D) Decreasing the volume of the reaction container will cause the equilibrium to shift to the right.
(E) Addition of He(g) will not shift the position of the equilibrium.

 Continued on next page

9. How many of the following substances will form **basic, acidic and neutral solutions** when dissolved in water?

BaO $HClO_4$ KNO_3 Li_2CO_3 NaF NH_4Br

	Basic	Acidic	Neutral
(A)	1	2	3
(B)	2	2	2
(C)	3	2	1
(D)	3	1	2
(E)	2	3	1

10. Arrange the following series of 0.1M aqueous solutions in **order of increasing pH (from lowest pH to highest pH)**:

$HClO$, $HClO_2$, $HClO_3$, $NaClO$, $NaClO_2$ and $NaClO_3$

(A) $HClO < HClO_2 < HClO_3 < NaClO < NaClO_2 < NaClO_3$

(B) $NaClO_3 < NaClO_2 < NaClO < HClO_3 < HClO_2 < HClO$

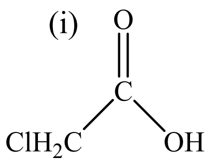
(C) $HClO_3 < HClO_2 < HClO < NaClO_3 < NaClO_2 < NaClO$

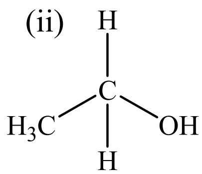
(D) $NaClO < NaClO_2 < NaClO_3 < HClO_3 < HClO_2 < HClO$

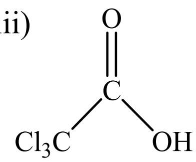
(E) $HClO_3 < HClO_2 < HClO < NaClO < NaClO_2 < NaClO_3$

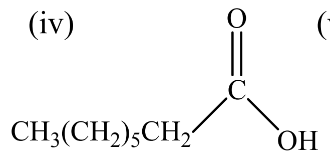
Name: ____________________ Student number: ______________

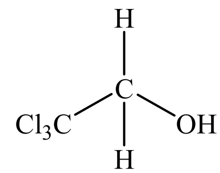
11. Rank the relative **acidity strength** of the following organic molecules from **lowest pK_a → highest pK_a**:

(i)


(ii)


(iii)


(iv)


(v)


(A) iv < i < ii < v < iii

(B) i < ii < v < iii < iv

(C) ii < v < iv < iii < i

(D) iii < v < i < iv < ii

(E) iii < i < iv < v < ii

12. Select the **TRUE** statement(s) about a solution that is mixed to be 0.010 M $MgCl_2$ and also 0.10 M NH_3. K_{sp} $(Mg(OH)_2) = 1.8 \times 10^{-11}$, K_b $(NH_3) = 1.8 \times 10^{-5}$.

(i) The concentration of OH^- available from solution is 1.3×10^{-3} M.

(ii) Q_{sp} $(Mg(OH)_2) = 1.3 \times 10^{-5}$ under these conditions.

(iii) A precipitate of $Mg(OH)_2$ will form.

(A) i

(B) ii

(C) iii

(D) i, iii

(E) ii, iii

13. When an airbag is deployed in a car, a series of three chemical reactions takes place. In the <u>second</u> reaction sodium metal and potassium nitrate react to produce a mixture of metal oxides and nitrogen gas. The *unbalanced* reaction is:

$$Na(s) + KNO_3(s) \rightarrow Na_2O(s) + K_2O(s) + N_2(g)$$

When the reaction is balanced with smallest whole number coefficients, the **coefficient of Na_2O** is:

(A) 10
(B) 5
(C) 4
(D) 2
(E) 1

14. Which of the following pairs of reagents would produce **<u>NO observable reaction</u>** when mixed together? (Assume solutions are all 0.10 M).

(A) $Zn(CH_3COO)_2(aq)$ and $Ag_2SO_4(aq)$
(B) $Pb(NO_3)_2(aq)$ and $CuCl_2(aq)$
(C) $Na_2CO_3(aq)$ and $HCl(aq)$
(D) $MgCl_2(aq)$ and $LiOH(aq)$
(E) $Zn(s)$ and $HI(aq)$

15. Which **ONE** of the following reactions is used to **define $\Delta H°_f$** for the given product?

(A) $2\ H_2(g)\ +\ O_2(g)\ \rightarrow\ 2\ H_2O(l)$
(B) $C(diamond)\ +\ O_2(g)\ \rightarrow\ CO_2(g)$
(C) $1/2\ Be_2(s)\ +\ H_2(g)\ \rightarrow\ BeH_2(s)$
(D) $1/2\ Br_2(l)\ \rightarrow\ Br(g)$
(E) $CaO(s)\ +\ CO_2(g)\ \rightarrow\ CaCO_3(s)$

16. A 20.0 g sample of a metal, initially at 5.00ºC, was placed in 25.0 mL of water, initially at 28.00ºC. The final temperature of the water and the metal was 27.12ºC. The specific heat of water is 4.184 J/g·K. Ignore the heat capacity of the container. If the density of water is 1.00 g/mL, what is the **specific heat** of the metal, in J/g·K?

(A) 0.21 J/g·K
(B) 0.50 J/g·K
(C) 1.0 J/g·K
(D) 2.6 J/g·K
(E) 7.7 J/g·K

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17. Identify which of the following are **extensive properties of a system**, where, as an example system, we consider a Tim Hortons™ large coffee with sugar, in an insulated mug.

(i) Volume
(ii) Internal Energy
(iii) Temperature
(iv) Sweetness
(v) Entropy

(A) i, ii
(B) i, iii, iv
(C) iii, iv, v
(D) ii, iii
(E) i, ii, v

18. For the combustion of the biodiesel component, $CH_3(CH_2)_8COOCH_2CH_3$ (l), balance the combustion reaction, and determine whether **work is done "ON" or "BY"** the system, and **what energy (in kJ/mol of biodiesel)** is associated with that work, at 298K.

(A) No work done, 0kJ
(B) BY, +12.4kJ
(C) ON, +12.4 kJ
(D) BY, +3.42 kJ
(E) ON, +3.42 kJ

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19. The caloric content of sucralose is equivalent to that of sucrose, whereas its relative sweetness (600x greater) is responsible for its “calorie free” reputation. The combustion 1.740 g of sucralose ($C_{12}H_{18}O_8Cl_4$) was performed in a bomb calorimeter. The bomb calorimeter has a heat capacity of 4.850 kJ/^oC. The initial temperature of the calorimeter was 20.48^oC, and the final temperature was 26.41^oC. What is the **enthalpy of combustion of sucralose, in kcal per gram**?

(A) – 4.0 kcal/g
(B) – 3.95 kcal/g
(C) – 3.9505 kcal/g
(D) – 3.9 kcal/g
(E) – 3.951 kcal/g

20. **Oxygen difluoride (OF_2)** is an unstable molecule that is a strong oxidizing agent used in various chemical processes. Calculate the **bond energy (kJ/mol)** of the **O-F bond** using the standard enthalpy of reaction (ΔH^o) involving water and the bond energy data provided below. The **unbalanced reaction** with water is shown below, with ΔH^o for the balanced reaction given:

$$OF_2\,(g) + H_2O\,(g) \rightarrow O_2\,(g) + HF\,(g) \qquad \Delta H^o = -318 \text{ kJ}$$

Bond Energy (kJ/mol):
O-H: 467; O-O: 145; O=O: 498; H-F: 565

(A) 188 kJ/mol
(B) −253 kJ/mol
(C) 506 kJ/mol
(D) 386 kJ/mol
(E) −14.5 kJ/mol

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21. The Haber-Bosch process is one of the most important industrial chemical processes for the synthesis of gaseous ammonia (NH_3) from H_2(g) and N_2(g). Which of the following statements is/are **TRUE** about the chemical reaction if $\Delta H° = -94.4$ kJ per mol of N_2:

(i) The reaction is exothermic ($\Delta H < 0$) because of the high bond energy of nitrogen.
(ii) The reaction is spontaneous at lower temperatures.
(iii) The reaction involves a decrease in entropy, $\Delta S < 0$.
(iv) The reaction is associated with negative work due to gas expansion.
(v) $S°$ (NH_3, g) > $S°$ (H_2, g).

(A) iii, v
(B) ii, iii, v
(C) i, ii
(D) iii, iv
(E) i, iv

22. Humans perspire as a way of keeping their bodies from overheating during strenuous exercise. The evaporation of the perspiration transfers heat from the body to the surrounding atmosphere. Calculate the total ΔS, in J/K, for evaporation of 5.00 g of water, if the skin is at 37.5°C, and the air temperature is at 23.5°C.

ΔH_{vap} for $H_2O(l) \rightarrow H_2O(g)$ is 44.0 kJ/mol at 37.5 °C

(A) −1.86 J/K
(B) +39.3 J/K
(C) +15.6 J/K
(D) −37.9 J/K
(E) +238 J/K

23. Select the **FALSE** statement from the following:

(A) The entropy of a system is a measure of its disorder as described by the number of available microstates at a given temperature.
(B) The standard enthalpy change for a chemical reaction can be calculated from the absolute enthalpies of reactants and products.
(C) For an equilibrium process, $\Delta H = T\Delta S$.
(D) For a spontaneous chemical reaction at 298K and 1 atm, $\Delta G° < 0$.
(E) $\Delta S < 0$ for the reaction $H_2(g) + O_2(g) \rightarrow HOOH(g)$.

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24. A train carrying four chemicals derails and spills the contents of 1 tank car only a few blocks from the McMaster campus. A clean up strategy is needed quickly, and depends on the identity of the substance. Unfortunately the railway company did not label their tanks very well, but as luck would have it, a bright Chemistry 1A03 student was close by at the time and able to make the following observations to identify the unknown chemical.

1) There was no evidence of reaction between the unknown chemical and an old copper penny the student was carrying.
2) The student was carrying epsom salts ($MgSO_4$) hoping to take a nice relaxing bath upon returning home. After dissolving the epsom salt in their water bottle, addition of salt to the unknown chemical showed no reaction.
3) Having just been to the grocery store, the student had some baking soda ($NaHCO_3$), which, upon addition to a small amount of the unknown chemical, reacted to produce gaseous CO_2.

The unknown chemical is:

(A) HCl
(B) NaOH
(C) HNO_3
(D) $Ba(OH)_2$
(E) H_2O

 Continued on next page

Questions 25 – 35 are worth 3 marks each.

25. Select the statements which are **FALSE**:

(i) Sucralose is an artificial sugar additive used to reduce total caloric intake since only small amounts are required to achieve sweetness similar to that of sucrose.

(ii) The dissolution of solid ammonium nitrate in water ("cold pack") is a spontaneous process since it is exothermic.

(iii) The decomposition reaction of sodium azide (NaN_3(s), found in airbags) to form Na and N_2 is a non-spontaneous process since the entropy change is negative.

(iv) Work is needed to condense CH_2FCF_3(g) prior to its circulation through a refrigerator as a liquid coolant. – not responsible for this statement (Fall 2008)

(v) Given that the hydrolysis of ATP into ADP is a spontaneous process, with $\Delta G°$ = -30.6 kJ, this process can be coupled to drive other non-spontaneous biochemical reactions.

(A) iv, v
(B) i, v
(C) iii, iv
(D) ii, iii
(E) i, iv, v

26. Balance the following reaction in **aqueous acidic medium**, and then choose the **TRUE** statements regarding the *balanced* spontaneous reaction.

$$MnO_4^-(aq) + SO_3^{2-}(aq) \rightarrow Mn^{2+}(aq) + SO_4^{2-}(aq)$$

(i) MnO_4^- is the oxidizing agent.

(ii) In the balanced reaction, the coefficient of the sulfate ion is 2.

(iii) The total number of electrons transferred in the balanced reaction is 10.

(iv) Mn^{2+} is a better reducing agent than SO_3^{2-}.

(v) $Q = [Mn^{2+}(aq)]^2\ [SO_4^{2-}(aq)]^5 / [MnO_4^-(aq)]^2\ [SO_3^{2-}(aq)]^5\ [H^+]^6$

(A) i, iii, v

(B) ii, iii

(C) ii, iv

(D) i, iii

(E) i, iv, v

27. Children's vitamin C supplement pills are recommended by Health Canada to have a maximum dosage less than 100 mg total calcium ascorbate ($CaC_6H_7O_6$, MW = 215.1933 g/mol). Calculate the **amount of calcium ascorbate (in mg)** in a children's vitamin pill that was crushed, filtered and dissolved in **10. mL** of deionized water, to form a solution whose **pH was measured to be 8.42**. Assume that no other acidic/basic chemicals are found in the pill and that pK_a = 4.30 for ascorbic acid at 25°C.

(A) 120 mg
(B) 75 mg
(C) 2.8 mg
(D) 34 mg
(E) 1500 mg

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28. In a 175 mL sample of HOCl(aq), the percent ionization of the acid is 3.82%. What is the **original molarity (M) of the HOCl(aq)**? ($K_a = 3.5 \times 10^{-8}$)

(A) 2.3×10^{-5} M

(B) 8.6×10^{-4} M

(C) 4.9×10^{-3} M

(D) 7.5×10^{-2} M

(E) 1.0×10^{-1} M

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29. Calculate the **molar enthalpy change** for the decomposition of 1 mole of $CaCO_3(s)$ into $CaO(s)$ and $CO_2(g)$ at room temperature and 1 atm. Use the fact that $\Delta H° = – 65.2$ kJ for the reaction $CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$, and any of the data below.

species	$H_2O(l)$	$Ca(OH)_2(s)$	$CaCO_3(s)$	$CO_2(g)$
$\Delta H°_f$ (kJ/mol)	–285.8	–986.6	–1206.7	–393.5

(A) 1064.6 kJ
(B) 385.3 kJ
(C) 177.6 kJ
(D) 65.2 kJ
(E) –374.0 kJ

 Continued on next page

30. Use any of the following data about acetic acid, CH_3COOH, to determine the energy needed to convert 6.01 g of acetic acid from 25.0°C to 150.°C.

Melting Point = +17°C

Boiling Point = +118°C

Heat Capacity [$CH_3COOH(l)$] = 123.3 J/K·mol

Heat Capacity [$CH_3COOH(g)$] = 66.5 J/K·mol

$\Delta H^o_{vaporization}$ = +23.36 kJ/mol

ΔH^o_{fusion} = +11.54 kJ/mol

(A) 135 kJ

(B) 21.9 kJ

(C) 4.27 kJ

(D) 3.70 kJ

(E) 1.36 kJ

 Continued on next page

31. A phase transition between two materials of the same composition, where both are in the solid-state, is known as a solid-solid phase transition, and has thermodynamic properties similar to other phase transitions we have discussed.

Taking advantage of the latent heat capacity of the solid-solid phase transition in salt hydrates, materials scientists have designed bricks which absorb solar energy during the day, and release that energy at night. For the concept to be successful, which of the following statements must be **TRUE**?

(i) The night time temperature must fall below the phase transition of the material.
(ii) The enthalpy change of the phase transition should be optimized, to be as small as possible.
(iii) The daytime temperature must be equal to or greater than the temperature of the phase transition.
(iv) $\Delta S_{tr} = \dfrac{\Delta H_{tr}}{T_{tr}}$, therefore ΔH_{tr} must be positive for the transition to occur spontaneously at T_{tr}.
(v) The material should be water-soluble.

(A) i, iii
(B) i, iii, iv
(C) v
(D) ii, iv
(E) ii, v

32. Rising industrial emissions of CO_2, a major greenhouse gas, have been associated with global climate change and increasing average surface temperature on Earth that has accelerated during the past 50 years. One strategy to **reduce CO_2 emissions** is to capture it prior to emission into the atmosphere and then chemically transform it into a stable yet useful commercial by-product. For example, the **synthesis of methanol** (CH_3OH) from CO_2 can be achieved using the following **unbalanced chemical reaction**:

$$CO_2\,(g) + H_2\,(g) \rightarrow CH_3OH\,(g) + H_2O\,(g)$$

Calculate the **equilibrium constant (K)** for the *balanced* reaction at 25ºC given the following information:

Chemical	**ΔH°_f (kJ/mol)**	**S° (J/mol K)**
CO_2 (g)	-393.5	213.7
H_2O (g)	-241.8	188.8
CH_3OH (g)	-200.7	239.8
H_2 (g)	0	130.7

(A) 2×10^{-1}

(B) 3×10^{2}

(C) 1×10^{13}

(D) 2×10^{-34}

(E) 4

33. Considering the following thermodynamic data, calculate the non-standard Gibbs free energy change, **ΔG, for the net ionic precipitation of $Ca(OH)_2(s)$** from $Ca^{2+}(aq)$ and $OH^{-}(aq)$**,** when $[OH^{-}] = 0.50$ M, $[Ca^{2+}] = 0.10$ M, and T = 298 K.

Species	$Ca(OH)_2(s)$	$Ca^{2+}(aq)$	$OH^{-}(aq)$
ΔG_f^o / (kJ/mol)	–898.56	–553.04	–157.30

(A) –10.06 kJ/mol of $Ca(OH)_2$

(B) –30.92 kJ/mol of $Ca(OH)_2$

(C) –23.50 kJ/mol of $Ca(OH)_2$

(D) –21.78 kJ/mol of $Ca(OH)_2$

(E) –44.06 kJ/mol of $Ca(OH)_2$

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34. Find the value of **ΔG^o (kJ)** under standard conditions, and the **temperature (K)** at which the reaction is spontaneous, from the following data:

$$N_2O_4(g) \rightleftarrows 2NO_2(g)$$

	ΔH^o	S^o	ΔG^o
$N_2O_4(g)$	11.1kJ/mol	304.4 J/mol.K	99.7 kJ/mol
$NO_2(g)$	33.2kJ/mol	240.1 J/mol.K	51.3 kJ/mol

(A) ΔG^o = 2.90 kJ/mol $N_2O_4(g)$, T = 298K

(B) ΔG^o = 3.80 kJ/mol $N_2O_4(g)$, T = 386K

(C) ΔG^o = -3.80 kJ/mol $N_2O_4(g)$, T = 342K

(D) ΔG^o = 2.90 kJ/mol $N_2O_4(g)$, T = 315K

(E) ΔG^o = -5.65 kJ/mol $N_2O_4(g)$, T = 364K

35. Given the following data at 298 K:

$\Delta H_f°$ (NF_3, g) = -124.7 kJ/mol

S° (NF_3, g) = 260.7 J/ K mol

S° (F_2, g) = 202.8 J/ K mol

S° (N_2, g) = 191.6 J/ K mol

Bond energy (N≡N) = 946 kJ/mol

Bond energy (F-F) = 159 kJ/mol

Determine which of the following statements is/are **CORRECT**:

(i) $N_2(g) + 3\ F_2(g) \rightarrow 2\ NF_3(g)$ is a formation reaction.

(ii) From the data given, at 298 K the bond energy for the N-F bond is 279 kJ/mol.

(iii) From the data given, $\Delta G_f°$ (NF_3, g) = -83.2 kJ/mol at 298 K.

(iv) $\Delta H°$ = 946 kJ for the reaction: $2\ N(g) \rightarrow N_2(g)$

(A) i

(B) i, iv

(C) ii

(D) ii, iii

(E) iii, iv

 Continued on next page

Name: ____________________ Student number: ______________

Some general data are provided on this page. Other data appear with the questions.

A periodic table is provided on the next page.

STP = 273.15 K, 1 atm

F = 96485 C/mol

R = 8.3145 J/K·mol = 0.08206 L·atm/K·mol

$N_A = 6.022 \times 10^{23}$ mol^{-1}

1 atm = 760 mm Hg = 101.325 kPa

0°C = 273.15 K

1 J = 1 kg m^2 s^{-2} = 1 kPa·L = 1 Pa·m^3

1 m = 10^9 nm = 10^{10} Å

1 cm^3 = 1 mL

1 g = 10^3 mg

1 Hz = 1 cycle/s

$c = 2.9979 \times 10^8$ m/s

$h = 6.6256 \times 10^{-34}$ Js

$m_e = 9.10 \times 10^{-31}$ kg

$\lambda = h / mv = h / p$

$\Delta x \Delta p \geq h / 4\pi$

$E_n = -R_H / n^2 = -2.178 \times 10^{-18} J / n^2$ (R_H is the energy form of the Rydberg constant for H)

$\Delta G = \Delta G^o + RT\mathit{ln}Q$

Specific heat of water = 4.184 J / g·°C

4.184 J = 1 cal

density(H_2O, l) = 1.00g/mL

density(H_2O, s) = 0.917g/mL

Solubility guidelines for Common Ionic Solids

Follow the lower-numbered guideline when two guidelines are in conflict. This leads to the correct prediction in most cases.

1. Salts of group 1 cations (with some exceptions for Li^+) and the NH_4^+ cation are soluble.
2. Nitrates, acetates, and perchlorates are soluble.
3. Salts of silver, lead, and mercury(I) are insoluble.
4. Chlorides, bromides, and iodides are soluble.
5. Carbonates, phosphates, sulfides, oxides, and hydroxides are insoluble (sulfides of group 2 cations and hydroxides of Ca^{2+}, Sr^{2+}, and Ba^{2+} are slightly soluble).
6. Sulfates are soluble except for those of calcium, strontium, and barium.

 Continued on next page

Name: ____________________ Student number: ______________

PERIODIC TABLE OF THE ELEMENTS

I 1	II 2	3	4	5	6	7	8	9	10	11	12	III 13	IV 14	V 15	VI 16	VII 17	VIII 18
		Transition Metals															
1 H 1.0079																	2 He 4.0026
3 Li 6.941	4 Be 9.0122											5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.180
11 Na 22.990	12 Mg 24.305											13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.066	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.88	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.69	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.224	41 Nb 92.906	42 Mo 95.94	43 Tc [98]	44 Ru 101.07	45 Rh 102.91	46 Pd 105.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 *La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.2	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po [209]	85 At [210]	86 Rn [222]
87 Fr [223]	88 Ra 226.03	89 **Ac 227.03	104 Unq [261]	105 Unp [262]	106 Unh [263]												

Atomic weights are based on $^{12}C = 12$ and conform to the 1987 IUPAC report values rounded to 5 significant digits. Numbers in [ ] indicate the most stable isotope.

* Lanthanides	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm [145]	62 Sm 150.36	63 Eu 151.97	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
** Actinides	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu [244]	95 Am [243]	96 Cm [247]	97 Bk [247]	98 Cf [251]	99 Es [252]	100 Fm [257]	101 Md [258]	102 No [259]	103 Lr [262]

 END OF EXAM