Answers June 2010

SECONDARY 5 CHEMISTRY

551-534

ANYONE WHO RECEIVES A COPY OF THIS EXAMINATION HAS

UNDERTAKEN TO USE IT ON THE FOLLOWING DATE:

June 14th, 2010

NOTE: This date was established by the DEEN and the Mathematics and Science & Technology Committee

Mathematics and Science & Technology Committee

Lester B. Pearson School Board

Commission scolaire Lester-B.-Pearson

JUNE 2010

CHEMISTRY 534

551-534

-EXAMINATION-

Guide

Mathematics and Science & Technology Committee

1. GENERAL INFORMATION

1.1 Program: Chemistry, Secondary V

1.2 Origin: Mathematics and Science & Technology Committee, 2010

Computerization by Martine Sanscartier, BIM, Société GRICS

Revision: Patricia Juliano, BIM, Société GRICS
Cheryl Cantin, BIM, Société GRICS

1.3 Time allotted: 3 hours

1.4 Number of questions: 29 questions distributed as follows
14 multiple-choice questions
15 constructed response (students select 11)

Structure of the Exam:

Part A: Fourteen (14) multiple-choice questions worth 4 marks each for a total of **56**%.

Part B: Four (4) questions on the **gases and their applications** of which the student is required to answer three (3). Each question is worth 4 marks for a total of **12**%.

Part C: Four (4) questions on **energy in chemical reactions** of which the student is required to answer three (3). Each question is worth 4 marks for a total of **12**%.

Part D : Three (3) questions on **rate of chemical reactions (kinetics)** of which the student is required to answer two (2). Each question is worth 4 marks for a total of **8**%.

Part E : Four (4) questions on **chemical equilibrium** of which the student is required to answer three (3). Each question is worth 4 marks for a total of **12**%.

1.5 Authorized material
- drawing instruments, graph paper
- scientific calculator with or without graphic display
- list of formulas and quantities included in the examination booklet
- periodic table of the elements included in the examination booklet
- a table of reduction potentials included in the examination booklet

2. DESCRIPTION OF THE EXAM

The following table matches each of the examination questions with the corresponding dimension of the definition of the domain that was used for the examination.

Exam Specifications

Topics / Skill	Gases and their Applications 28%	Energy in Chemical Reactions 28%	Rate of Chemical Reactions 16%	Equilibrium in Chemical Reactions 28%
Mastery of Concepts 24% – 28%*	1, 3, 4, 15	7, 19	9, 23	11, 12, 26
Mastery of Applications 36% – 52%*	2, 17	5, 6, 8	10	13, 14, 29
Mastery of Problem- Solving Techniques 28% – 36%*	16, 18	20, 21, 22	24, 25	27, 28

The numbers on the centre of each box above represent the question numbers in the examination.
*Depending on questions chosen.

The examination consists of the following types of questions:
14 multiple-choice questions (numbers 1 - 14) that test the student's mastery of concepts and applications.
11 of 15 constructed-response questions (numbers 15 - 29) that test the student's mastery of concepts, applications and problem solving.

Student selection of problems
When a student answers more than the number of questions required, without indicating which ones are to be corrected, **only the first ones are to be corrected**. Thus, for example, if a student is to choose two out of three questions and answers all three, only the first two are to be corrected.

Item Specifications

Question		MOD.TO.IO	T	S	D
Part A					
1	[2299]	M02.03	M	C	E
2	[2300]	M02.02.01	M	A	M-D
3	[2301]	M02.02.05	M	C	M
4	[2302]	M02.03.02	M	C	E
5	[2303]	M03.02	M	A	D
6	[2304]	M03.02.03	M	A	M
7	[2305]	M03.01	M	C	E-M
8	[2306]	M03.02.05	M	A	D
9	[2307]	M04.02.02	M	C	M
10	[2308]	M04.02.03	M	A	M
11	[2309]	M05.01.02	M	C	E
12	[2310]	M05.01.01	M	C	E
13	[2311]	M05.03.02	M	A	M
14	[2312]	M05.03	M	A	M
Part B					
15	[2313]	M02.02	E	C	E
16	[2314]	M02.02.06	E	P	M
17	[2315]	M02.02.04	E	A	E
18	[2316]	M02.02.09	E	P	M
Part C					
19	[2317]	M03.01.01	E	C	E
20	[2318]	M03.02.06	E	P	D
21	[2319]	M03.02.04	E	P	M
22	[2320]	M03.02.02	E	P	M
Part D					
23	[2321]	M04.02.01	E	C	E
24	[2322]	M04.01.02	E	P	D
25	[2323]	M04.01.02	E	P	M
Part E					
26	[2324]	M05.01.03	E	C	M
27	[2325]	M05.02.06	E	P	M
28	[2326]	M05.02.06	E	P	D
29	[2327]	M05.03	E	A	M

Legend:

MOD : Modules
- M02: Gases and Their Applications
- M03: Energy in Chemical Reactions
- M04: Rate of Chemical Reactions
- M05: Equilibrium in Chemical Reaction

TO: Terminal objective

IO: Intermediate objective

T : Type
- M : multiple-choice
- C : short-answer
- E : extended-answer (constructed response)

S : Skill
- C : Mastery of Concepts
- A : Mastery of Application
- P : Mastery of Problem-Solving Techniques

D : Level of difficulty
- E: Easy
- M: Medium
- D: Difficult

3. CORRECTION KEY

Part A

4 marks or 0 marks

1	C
2	C
3	D
4	A
5	B
6	D
7	C
8	D
9	B
10	B
11	A
12	D
13	C
14	A

GUIDELINES FOR CORRECTING CONSTRUCTED-RESPONSE QUESTIONS

Below is an explanation of the terms found in the marking scale to be used for scoring the answers to the constructed response questions in the examination.

It is **IMPORTANT** that the teacher read this information carefully before correcting the examination.

Constructed-response questions usually consist of two parts: the **procedure** used to solve the problem and the **answer**. Thus, a constructed-response question should be corrected in two steps.

Step 1

Analyze the work to understand the procedure used by the student, and then decide if the procedure is appropriate or not.

A **procedure** is **appropriate** if the steps presented could lead to the correct answer.

A **procedure** is **partially appropriate** if the steps presented do not lead to the correct answer, but include at least one step that is relevant and correct.

A **procedure** is **inappropriate** if none of the steps presented are relevant or if the student has not shown any work.

Step 2

If the procedure is deemed appropriate, then evaluate the answer. If the answer is incorrect, identify the type of error made.

The **error** is considered **minor** if it is an error in calculation or transcription, if the unit of measurement is incorrect or missing, or if the student has rounded off a number incorrectly.

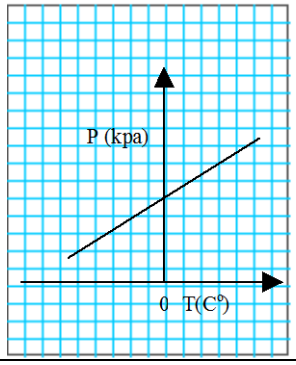
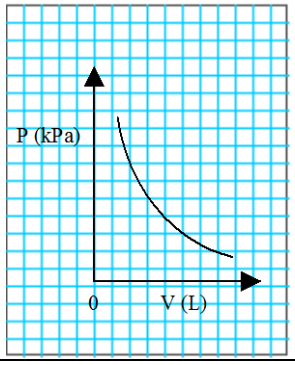
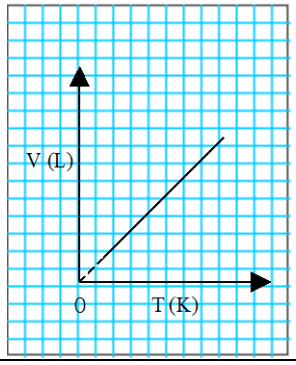
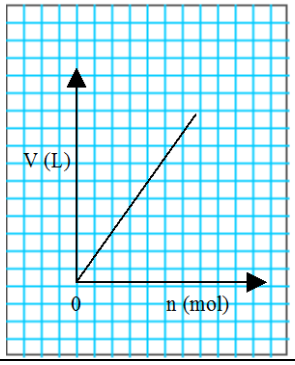
The **error** is considered **major** if a law, rule, or formula has been applied incorrectly.

No marks are allotted for a correct answer when the procedure used is inappropriate.

All extended answers have been worked out using significant figures. However, do not penalize students if they do not consider significant figures.

Part B

15 **Example of an appropriate and complete solution** /4

Graph A	Graph B
	
Graph C	**Graph D**
	

Allot 1 mark per correct graph. Axes must be labelled.

Do not penalize a student who has drawn a solid line in graph C.

Do not penalize student who has not shown negative values in graph A.

16 **Example of an appropriate and complete solution** /4

$V = 5000.0$ L
$P = 250.0$ kPa
$T = 2.0°C + 273 = 275$ K

$$n\ Cl_{2(g)} = \frac{PV}{RT}$$
$$= \frac{250.0\ \text{kPa} \times 5000.0\ \text{L}}{\frac{8.314\ \text{kPa}}{\text{mol} \bullet \text{K}} \times 275\ \text{K}}$$

$n\ Cl_{2(g)} = 5.47 \times 10^2$ mol

5.47×10^2 mol $Cl_2 \times 70.90$ g/mol $= 3.88 \times 10^4$ g Cl_2

$$D = \frac{m}{V}$$
$$= \frac{3.88 \times 10^4\ \text{g}}{5000.0\ \text{L}}$$
$$D = \frac{7.76\ \text{g}}{\text{L}}$$

Answer: The density of the chlorine gas is $\frac{\mathbf{7.76\ g}}{\mathbf{L}}$ **or 0.00776 g/mL**

4 marks Appropriate and complete procedure.

3 marks Appropriate procedure with a minor error such as calculation or transcription error.

2 marks Appropriate procedure with a major error such as an incorrect application of a law, formula or rule.

1 mark Partially appropriate and correctly completed procedure.

0 marks Inappropriate procedure or did not show the procedure, regardless of the answer.

17 **Example of an appropriate and complete solution** /4

Determine mol of H_2

$$x \text{ mol} = \frac{\text{mass}}{\text{molar mass}}$$
$$= \frac{18\,860\,000 \text{ g}}{2.02 \text{ g/mol}}$$
$$= 9\,337\,000 \text{ mol}$$

Therefore the number of moles of Helium is 9 337 000 mol

Mass of Helium

$$9\,337\,000 \text{ mol} = \frac{x \text{ g}}{4.00 \text{ g/mol}}$$
$$= \textbf{37 400 000 g} \text{ or } \textbf{37 350 kg} \text{ helium}$$

Answer: The mass of helium, $He_{(g)}$, required to fill the Hindenburg at the same temperature and pressure is **37 400 000 g** or **37 400 kg**.

4 marks Appropriate and correct answer.

3 marks Appropriate procedure with minor error such as calculation or transcription error

2 marks Appropriate procedure with a major error such as the incorrect application of a law, formula, or rule.

1 mark Partially appropriate and correctly completed procedure.

0 marks Inappropriate procedure or did not show the procedure, regardless of the answer.

18 **Example of an appropriate and complete solution** /4

Number of moles of CO_2

$$\frac{1000 \text{ g of Fe}}{55.85 \text{ g/mol}} \times \frac{3 \text{ CO}_2}{2 \text{ Fe}} = 26.9 \text{ moles}$$

Volume of CO_2

$$\frac{nRT}{P} = \frac{26.9 \text{ moles} \times 8.31 \text{ kPa/mol} \bullet \text{K} \times 393 \text{ K}}{98.0 \text{ kPa}}$$

$$= 896 \text{ L}$$

Answer: The volume of CO_2 gas released for each kilogram of iron produced is **896 L**.

4 marks Appropriate and correct answer.

3 marks Appropriate procedure with minor error such as calculation or transcription error

2 marks Appropriate procedure with a major error such as the incorrect application of a law, formula, or rule.

1 mark Partially appropriate and correctly completed procedure.

0 marks Inappropriate procedure or did not show the procedure, regardless of the answer.

Part C

19 **Example of an appropriate and complete solution** /4

Possible explanations

A. The graph given **could** represent this change.

Explanation: Photosynthesis requires sunlight as an energy source to assemble simple molecules into more complex structures. Since energy is being absorbed during the process, enthalpy is increasing as indicated on the graph.

B. The graph given **could not** represent this change.

Explanation: As bonds are formed to change liquid water into ice, energy will be released to the surroundings. Therefore the ice that forms will have less enthalpy than the liquid water. The graph shows an increase in enthalpy.

Note Simply identifying the change as endothermic or exothermic is not an appropriate explanation.

Allot 1 mark for each correct answer with an appropriate explanation.

Allot 1 sole mark for each correct explanation.

20 **Example of an appropriate and complete solution** /4

4623 kJ released per 1 mole of $AlCl_3$.

$\therefore \dfrac{116 \text{ kJ}}{4623 \text{ kJ/mol}} = 0.02501$ mol of $AlCl_3$.

$NH_4ClO_{4(s)}$ and $AlCl_{3(s)}$ in a 3:1 mol ratio

So 0.0251 mol of $AlCl_{3(s)}$ is produced from 0.0753 mol of $NH_4ClO_{4(s)}$

0.0753 mol × 117.5 g/mol = **8.85 g of** $NH_4ClO_{4(s)}$

Answer: **8.85 g of** $NH_4ClO_{4(s)}$ were used.

4 marks Appropriate and complete procedure.

3 marks Appropriate procedure with a minor error such as calculation or transcription error, or units of measurement missing.

2 marks Appropriate procedure with a major error such as the incorrect application of a law, formula, or rule.

1 mark Partially appropriate and correctly completed procedure.

0 marks Inappropriate procedure or did not show the procedure, regardless of the answer.

21 **Example of an appropriate and complete solution** /4

Reverse Equation 1, multiply by 16 and reverse sign for ΔH:

$$16\ H_2S_{(g)} \rightarrow 16\ H_{2(g)} + 2\ S_{8(g)} \qquad \Delta H = +321.6\ kJ$$

Reverse Equation 2, multiply by 8 and reverse sign for ΔH:

$$8\ SO_{2(g)} \rightarrow S_{8(s)} + 8\ O_{2(g)} \qquad \Delta H = +2368.8\ kJ$$

Select Equation 4 and not 3 since the former contains the needed gaseous H_2O. Multiply by 16.

$$16\ H_{2(g)} + 8\ O_{2(g)} \rightarrow 16\ H_2O_{(g)} \qquad \Delta H = -4572.8\ kJ$$

Sum: $16\ H_2S_{(g)} + 8\ SO_{2(g)} \rightarrow 3\ S_{8(s)} + 16\ H_2O_{(g)} \qquad \Delta H = -1882.4\ kJ$

Answer: The heat reaction, $\Delta \boldsymbol{H}$ is **-1882.4 kJ**.

4 marks Appropriate and complete procedure.

3 marks Appropriate procedure with a minor error such as calculation or transcription error.

2 marks Appropriate procedure with a major error such as an incorrect application of a law, formula or rule.

1 mark Partially appropriate and correctly completed procedure.

0 marks Inappropriate procedure or did not show the procedure, regardless of the answer.

22 **Example of an appropriate and complete solution** /4

Density of water is 1.00 g/mL therefore, mass of water used is 200.0 g.
Specific heat capacity of water is 4.19 J/g•°C

$Q = mc\Delta T$
$Q = 200.0\ \text{g} \times 4.19 \times (7.0°\text{C} - 18.0°\text{C})$
$Q = -9220\ \text{J}$

$$\Delta H = -\frac{Q}{n}$$

therefore, $$n = \frac{-Q}{H}$$

$$= \frac{-(-9.22\,\text{kJ})}{+34.9\,\text{kJ}}$$

$= 0.264$ mol of KNO_3

Molar mass of KNO_3 = 101.11 g/mol

0.264 mol × 101.11 g/mol = 27 g of KNO_3

Answer: The mass of solid **KNO_3** that was added is **27 g**.

4 marks Appropriate and complete procedure.

3 marks Appropriate procedure with a minor error such as calculation or transcription error, or units of measurement missing.

2 marks Appropriate procedure with a major error such as the incorrect application of a law, formula, or rule.

1 mark Partially appropriate and correctly completed procedure.

0 marks Inappropriate procedure or did not show the procedure, regardless of the answer.

Part D

23 **Example of an appropriate and complete solution** /4

Possible explanations

A. Required Action: Use a rubber stopper with a valve so that the pressure in the bottle can be lowered.

Explanation: Lowering the pressure reduces the concentration of the oxygen resulting in fewer collisions between the molecules producing a reduced reaction rate.

B. Required Action: Stand the sealed wine bottle upright.

Explanation: Standing the sealed bottle upright would reduce the surface area of the wine exposed to oxygen resulting in fewer collisions between the molecules producing a reduced reaction rate.

Allot 2 marks for each correct answer with an appropriate explanation; 1 mark for the choice of action and 1 mark for the explanation.

24 **Example of appropriate and complete responses** /4

The change in temperature during the first 120 seconds

$$100°C - 25°C = 75°C$$

Mass of butane used

$$\frac{75°\,C \times 1\,g}{10.0°C} = 7.5\ g$$

Mass of oxygen consumed

$$\frac{7.5\ g}{58.14\ g/mol} \times \frac{13\,O_2}{2\,C_4H_{10}} \times 32.00\ g/mol = 27\ g$$

Rate of consumption of oxygen gas

$$\frac{27\ g}{120\ s} = 0.23\ g/s$$

Answer: The average rate of consumption of oxygen gas, O_2, in the first 120 seconds is **0.23 g/s.**

4 marks Appropriate and complete procedure.

3 marks Appropriate procedure with a minor error such as calculation or transcription error, or units of measurement missing.

2 marks Appropriate procedure with a major error such as the incorrect application of a law, formula, or rule.

1 mark Partially appropriate and correctly completed procedure.

0 marks Inappropriate procedure or did not show the procedure, regardless of the answer.

25 **Example of an appropriate and complete solution** /4

Rate of consumption of N_2O_5

At 100 minutes: 0.00094 mol N_2O_5

At 40 minutes: 0.00531 mol N_2O_5

$$\frac{(0.00094\,\text{mol} - 0.00531\,\text{mol})}{100.0\,\text{min} - 40.0\,\text{min}} = -7.3 \times 10^{-5}\ \text{mol/min}\ N_2O_5$$

-7.3×10^{-5}mol/min $N_2O_5 \times 2$ mol NO_2/-1 mol $N_2O_5 = 1.5 \times 10^{-4}$ mol/min NO_2

Answer: The average rate of production of nitrogen dioxide, NO_2, is **1.5×10^{-4} mol/min NO_2**

4 marks Appropriate and complete procedure.

3 marks Appropriate procedure with a minor error such as calculation or transcription error, or units of measurement missing.

2 marks Appropriate procedure with a major error such as the incorrect application of a law, formula, or rule.

1 mark Partially appropriate and correctly completed procedure.

0 marks Inappropriate procedure or did not show the procedure, regardless of the answer.

Part E

26 **Example of an appropriate and complete solution** /4

A) Reactants (reverse reaction) are favoured. According to Le Chatelier's Principle, the system will shift in such a direction to reduce excess heat to re-establish equilibrium. In order to reduce the excess heat the endothermic direction is favoured. This is the reverse reaction.

B) No shift occurs. Only changes in concentration affect change in an equilibrium system (based on the rate laws). Since the water is in a liquid state, increasing the amount of water does not change its concentration. No shift will occur.

C) Reactants (reverse reaction) are favoured. The removal of hydrogen decreases its concentration. According to LeChatelier's Principle the reverse reaction will speed up in order to replace the hydrogen removed until a new equilibrium is established.

D) Reactants (reverse reaction) are favoured. As the volume is increased the gas pressure is decreased. There are a greater number of moles of gas molecules on the reactant side than there are on the product side. According to le Chatelier's Principle, the equilibrium will shift in a direction that will increase pressure lost. This means the equilibrium will shift toward the side with the greater number moles of gas, which is the reactant side.

Allot 1 mark for each correct answer with an appropriate explanation.

Allot 1 sole mark to students who correctly stated how the equilibrium system would or would not shift, but provided inadequate or no explanation.

27 **Example of an appropriate and complete solution** /4

Eliminate the solid.

	4 HF	UF_4	2 H_2O
I	0.25 mol/L	0	0
C	-0.20	+0.05	+0.10
E	0.05	0.05	0.10

Solve for K_c

$$K_c = \frac{[UF_{4(g)}][H_2O_{(g)}]^2}{[HF_{(g)}]^4}$$

$$= \frac{(0.05)(0.10)^2}{(0.05)^4}$$

$$= 80$$

Answer: The equilibrium constant is **80**.

4 marks Appropriate and complete procedure.

3 marks Appropriate procedure with a minor error such as calculation or transcription error.

2 marks Appropriate procedure with a major error such as the incorrect application of a law, formula, or rule.

1 mark Partially appropriate and correctly completed procedure.

0 marks Inappropriate procedure or did not show the procedure, regardless of the answer.

28 **Example of an appropriate and complete solution** /4

Citric acid

$[H^+] = 10^{-3.70}$
$= 2.0 \times 10^{-4}$ mol/L

$$K_a = \frac{\left(2.0\times10^{-4}\right)^2}{\left(0.12 - 2.0\times10^{-4}\right)}$$
$= 3.3 \times 10^{-7}$

Boric acid

$$K_a = \frac{\left(2.1\times10^{-5}\right)^2}{\left(0.75 - 2.1\times10^{-5}\right)}$$
$= 5.9 \times 10^{-10}$

Answer: The strongest acid is **citric acid.**

Note: A student who uses percent ionization should be given full marks.

4 marks Appropriate and complete procedure.

3 marks Appropriate procedure with a minor error such as calculation or transcription error.

2 marks Appropriate procedure with a major error such as the incorrect application of a law, formula, or rule.

1 mark Partially appropriate and correctly completed procedure.

0 marks Inappropriate procedure or did not show the procedure, regardless of the answer.

29 **Example of an appropriate and complete solution** /4

a) $3\ Cu^{+}_{(aq)} + Cr_{(s)} \leftrightarrow 3\ Cu_{(s)} + Cr^{3+}_{(aq)}$ 1 mark

b) 1.26 V 1 mark

c) Increase the concentration of $CuNO_{3(aq)}$ or decrease the concentration of $Cr(NO_3)_{3(aq)}$. 1 mark

d) It allows the anions to move towards the anode, and the cations to move towards the cathode. It prevents the build up of excess anions and cations in the electrochemical cell. 1 mark

Allot1 mark for each correct answer.

Mathematics and Science & Technology Committee

Evaluation questionnaire

Please take the time to complete this questionnaire on the overall validity and quality of this examination.

You are asked to submit your overall impression and specific comments on several aspects of this examination: the quality of the exam, the appropriateness of the vocabulary and problems encountered.

Your comments and suggestions will be helpful in guiding teachers who will work on exam-development teams next year.

Please return the completed questionnaire to the educational services department of your school board as soon as the exam has been administered.

School boards are asked to send the questionnaires they receive to the address below before July 15th.

Thank you for your cooperation.

Banque d'Instruments de Mesure (BIM)
Société GRICS
5100, rue Sherbrooke est
Bureau 300 (3e étage)
Montréal (Québec)
H1V 3R9

QUESTIONNAIRE

CHEMISTRY **June 2010**

- **How difficult is this exam?**

☐ Very difficult ☐ Difficult ☐ Average ☐ Easy ☐ Very easy

- **How suitable is the vocabulary for your students?**

☐ Excellent ☐ Very good ☐ Good ☐ Fair

- **Which questions, if any, were problematic? Why?**

- **Which questions, if any, were inappropriate (too easy, hard, etc.)? Why?**

- **What problems, if any, did you encounter administering or correcting this exam?**

- **On average, how much time did your students need to finish this exam?**
  _____ minutes

- **On this exam, were your student's marks higher, lower, or the same as their yearly average? If there is a variation, please indicate the magnitude.**

  _____

  _____

- **Are there any questions you would have modified? Which ones? Why?**

  _____

  _____

  _____

  _____

- **Overall impression of the exam and other comments:**

  ☐ Excellent ☐ Very good ☐ Good ☐ Fair

  _____

  _____

  _____

  _____

  _____

Teacher: _____

School: _____

School Board: _____

Return to: **BIM,** Société GRICS, 5100 Sherbrooke Est, Bureau 300 (3e étage), Montréal, H1V 3R9 Fax: (514) 251-3920

Lester B. Pearson School Board

Commission scolaire Lester-B.-Pearson

JUNE 2010

CHEMISTRY 534

551-534

-EXAMINATION-

Question Booklet

3 hours

Mathematics and Science & Technology Committee

INSTRUCTIONS

1. Write the required information on the title page of the **Answer Booklet**.

2. Answer all questions in the **Answer Booklet**. Each question is worth four marks.

3. In Part B, you are to answer **3 of the 4** questions. If you answer all 4 questions in this section, **draw a line through the question that you do not want to have corrected**. If you do not, the first 3 questions will be corrected.

4. In Part C, you are to answer **3 of the 4** questions. If you answer all 4 questions in this section, **draw a line through the question that you do not want to have corrected**. If you do not, the first 3 questions will be corrected.

5. In Part D, you are to answer **2 of the 3** questions. If you answer all 3 questions in this section, **draw a line through the question that you do not want to have corrected**. If you do not, the first 2 questions will be corrected

6. In Part E, you are to answer **3 of the 4** questions. If you answer all 4 questions in this section, **draw a line through the question that you do not want to have corrected**. If you do not, the first 3 questions will be corrected.

7. You may use drawing instruments, graph paper and a scientific calculator with or without graphing display.

8. You may refer to the lists of formulas, quantities, and tables included in the Appendix to this Question Booklet. The use of any other source of reference is strictly forbidden.

9. Hand in both the Question Booklet and the Answer Booklet at the end of the exam session.

Note: Figures are **NOT** necessarily drawn to scale.

Time allotted

3 hours

Part A **Questions 1 to 14**

Blacken the letter that corresponds to your answer in the answer booklet.

1 A metal cylinder is filled with oxygen gas (O_2) to a pressure of 75 kPa at a temperature of 25°C. A second identical metal cylinder is filled to the same pressure and temperature with methane gas (CH_4). Assume that both gases are behaving like ideal gases.

Which of the following statements is FALSE?

A) The molecules of oxygen and the molecules of methane have the same average kinetic energy.

B) The number of molecules of oxygen is equal to the number of molecules of methane.

C) The collisions between oxygen molecules result in a greater loss in kinetic energy than the collisions between methane molecules.

D) The average velocity of the oxygen molecules is less than the average velocity of the methane molecules.

2 When studying scuba diving one learns that every for 10.0 m of water depth, the pressure on a submerged object increases by 100.0 kPa, assuming the temperature remains constant.

In an experiment, a balloon filled with air was held at the surface of a lake. Before being submerged**,** it had an initial volume of 400.0 mL under an initial pressure of 100.0 kPa. The balloon was then submerged until its volume decreased to 84.0 mL.

To what depth was the balloon submerged?
(Assume that the temperature remained constant.)

A) 23.8 m
B) 35.7 m
C) 37.6 m
D) 47.6 m

3 A balloon is filled with a gas and the initial conditions are recorded. The conditions are then changed so that the pressure is halved, the number of gas molecules is tripled, and the Kelvin temperature is doubled.

Which of the following statements is correct?
(Assume the gas behaves like an ideal gas.)

A) The final volume is the same as the initial volume.

B) The final volume is 3 times larger than the initial volume.

C) The final volume is 6 times larger than the initial volume.

D) The final volume is 12 times larger than the initial volume.

4 The air spaces in soil contain oxygen (O_2), carbon dioxide (CO_2), and nitrogen (N_2). These gases freely diffuse throughout the air spaces.

The diffusion of the gases was measured in the morning, when the soil temperature was 15°C, and during the afternoon when the soil temperature was 31°C.

In which of the following combinations is the fastest diffusing gas correctly paired with the slowest diffusing gas?

A) Fastest: nitrogen at 31°C
Slowest: carbon dioxide at 15°C

B) Fastest: oxygen at 31°C
Slowest: carbon dioxide at 15°C

C) Fastest: nitrogen at 15°C
Slowest: carbon dioxide at 31°C

D) Fastest: carbon dioxide at 31°C
Slowest: nitrogen at 15°C

5 Phileas Fogg, the character who went around the world in 80 days, was very fussy about his bathwater temperature. It had to be exactly 38.0°C.

One morning his bath water temperature was 40.0°C. To cool the 100.0 kg of water to the desired temperature, his servant Passepartout added several 3.0 kg aluminum duckies that he stored in the freezer at a temperature of -24.0°C.
The specific heat capacity of aluminum is c = 0.897 J/g °C.

How many 3.0 kg aluminum duckies were needed to cool the bath water to the desired 38.0°C temperature? (Assume no heat is lost to the air.)

A) 1 duckie
B) 5 duckies
C) 8 duckies
D) 15 duckies

6 A calorimeter contains 60.0 mL of 1.0 mol/L $NaOH_{(aq)}$ at an initial temperature of 21.7°C. To this solution, 30.0 mL of 2.0 mol/L $HCl_{(aq)}$ is added at the same temperature. After the neutralization reaction comes to completion, the final temperature of the resulting solution is 29.5°C.

What is the molar heat of neutralization of $HCl_{(aq)}$?
(Assume the density and specific heat for all solutions to be equal to that of water.)

A) -1.5 kJ/mol
B) -2.9 kJ/mol
C) -16 kJ/mol
D) -49 kJ/mol

7 A student is trying to find the heat of solution (ΔH) for potassium hydroxide (KOH). She adds 5.0 g of potassium hydroxide (KOH) to 100.0 mL of distilled water at 18˚C. She notes that the temperature of the resulting solution is 29°C.

Consider the following statements:

I. The dissolving of potassium hydroxide (KOH) in water is an endothermic process.
II. The amount of energy required to break the bonds in the solid potassium hydroxide (KOH) is less than the amount of energy released into the potassium hydroxide (KOH) solution.
III. The enthalpy of the resulting solution is greater than the sum of the enthalpies of the original substances.
IV. The ΔH for this process will have a negative value.

Which of these statements are correct?

A) I and II only
B) I and III only
C) II and IV only
D) III and IV only

8 Your chemistry teacher has assigned a lab experiment to determine the energy produced during the combustion of **1 mole** of ethanol, C_2H_5OH.

The equation of the reaction is:

$$C_2H_5OH_{(l)} + 3\ O_{2(g)} \rightarrow 2\ CO_{2(g)} + 3\ H_2O_{(g)}$$

Wanting to know the results, you check in your chemistry book. You find the following equations:

$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)} + 394$ kJ

$H_{2(g)} + ½\ O_{2(g)} \rightarrow H_2O_{(g)} + 242$ kJ

$2\ C_{(s)} + 3\ H_{2(g)} + ½\ O_{2(g)} \rightarrow C_2H_5OH_{(l)} + 277$ kJ

Based on your findings, which of the following values would you submit to your teacher, before you start the experiment?

A) $\Delta H = 875$ kJ/mol

B) $\Delta H = -1003$ kJ/mol

C) $\Delta H = -1791$ kJ/mol

D) $\Delta H = -1237$ kJ/mol

9 Chemical reactions can be classified according to the rate of their reactions.
Rank the following reactions in decreasing order of rate.

1. $2\ HCl_{(aq)} + Mg_{(s)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$

2. $Ag^+_{(aq)} + NO^-_{3(aq)} + Na^+_{(aq)} \rightarrow AgCl_{(s)} + Na^+_{(aq)} + NO^-_{3(aq)}$

3. $C_6H_{12}O_{6(aq)} \xrightarrow{\text{yeast}} 2\ CH_3CH_2OH_{(l)} + 2\ CO_{2(g)}$

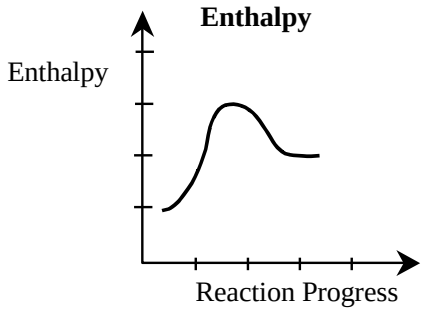
A) 1, 2 and 3 C) 2, 3 and 1

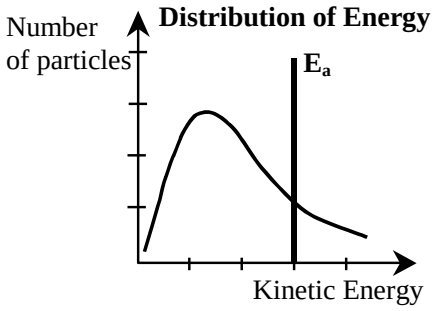
B) 2, 1 and 3 D) 3, 2 and 1

10 The following chemical reaction takes place at 25.0°C:

$$A_{(g)} + B_{(g)} + \text{Heat energy} \rightarrow C_{(g)}$$

The two graphs below correspond to the reaction above.



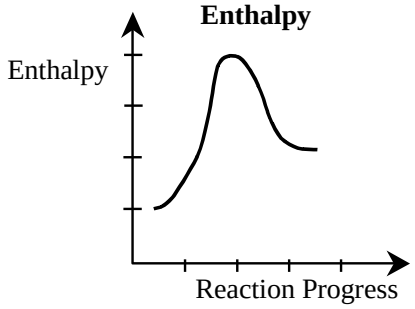


The chemical reaction is then observed while it is independently subjected to two different stresses.

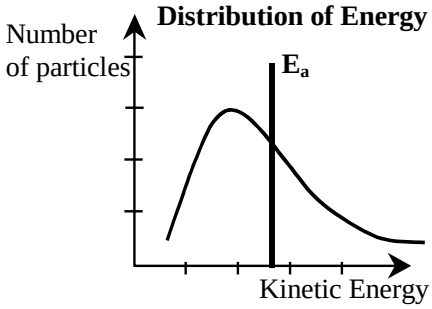
Stress 1: An inhibitor is added to the system.
Stress 2: The temperature of the system is decreased.

Which combination correctly matches stress and graph?

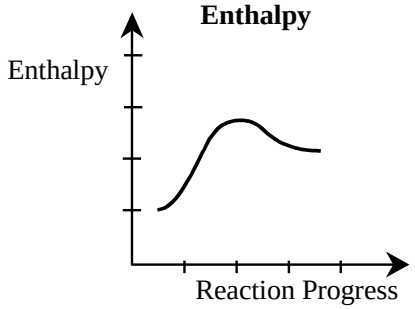
Graph 1



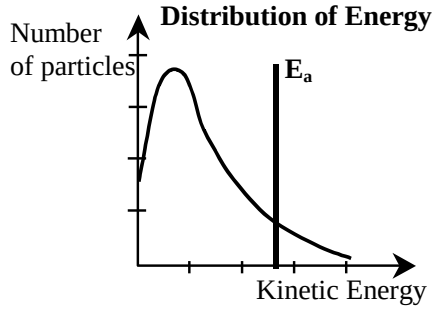
Graph 3



Graph 2



Graph 4



A) Stress 1 and Graph 1
Stress 2 and Graph 3

B) Stress 1 and Graph 1
Stress 2 and Graph 4

C) Stress 1 and Graph 2
Stress 2 and Graph 3

D) Stress 1 and Graph 2
Stress 2 and Graph 4

11 The following four systems have reached equilibrium; their equilibrium constants are given.

1. $BaSO_{4(s)} \leftrightarrow Ba^{+2}_{(aq)} + SO_4^{-2}{}_{(aq)}$ $K_{eq} = 1.1 \times 10^{-10}$

2. $2\ NO_{2(g)} \leftrightarrow N_2O_{4\,(g)}$ $K_{eq} = 2.15 \times 10^{2}$

3. $2\ SO_{2(g)} + O_{2(g)} \leftrightarrow 2\ SO_{3(g)}$ $K_{eq} = 8.0 \times 10^{1}$

4. $NaHCO_{3(s)} \leftrightarrow NaOH_{(s)} + CO_{2(g)}$ $K_{eq} = 1.0 \times 10^{0}$

Rank these reactions in increasing order of their tendency to favour the products.

A) 1, 4, 3 and 2
C) 3, 4, 1 and 2
B) 2, 3, 4 and 1
D) 4, 1, 3 and 2

12 **Which of the following situations represents a state of dynamic equilibrium?**

A) The combustion of gasoline in a car's engine
B) A human being at 37.0°C and constant body weight
C) A constant volume of water in a bathtub, tap flowing and drain open
D) A sealed bottle of Ginger Ale

13 The ionization constant for water, K_w at 25°C is 1×10^{-14} and at 100°C it is 5.13×10^{-13}.

What is the pH of the water sample at 100°C?

A) 1.00×10^{-7}
C) 6.15
B) 7.16×10^{-7}
D) 7.00

14 The information below was collected from an experiment on the reactivity of metals.

$Pd^{2+}_{(aq)} + Tl_{(s)} \rightarrow$ reaction

$Tl^{3+}_{(aq)} + V_{(s)} \rightarrow$ reaction

$Pd^{2+}_{(aq)} + Pt_{(s)} \rightarrow$ no reaction

Which combination below lists these elements in decreasing order of their tendency to undergo oxidation?

A) V, Tl, Pd and Pt
C) Pt, Pd, Tl and V
B) V, Pd, Tl and Pt
D) Tl, Pt, V and Pd

Parts B, C, D, and E of the examination comprise questions for which you must show all your work.
Answer these questions in the answer booklet. Show all the work needed to solve the problem: **data given, explanations, formulas** and **calculations**. Then write your answer in the space provided.
You will be given no marks if you provide the right answer without showing your work. However, you will be given part marks for work that is partially correct. Where necessary, **the correct unit of measurement must be included in the answer**; however, significant figures will not be considered.

Part B Questions 15, 16, 17, and 18 (Answer **three** questions only.)

If you answer all questions in this section, **draw a line through the question that you do not want to have corrected**. If you do not, questions 15, 16 and 17 will be corrected.

15 **The behaviour of an ideal gas can be represented graphically. Sketch the mathematical relationship for each of the following situations using the axes given in the Answer Booklet. Be sure to label the axes.**

Graph A – Pressure (kPa) as a function of temperature (°C) when the volume and number of moles of gas are constant.

Graph B – Pressure (kPa) as a function of volume (L) when the temperature and the number of moles are constant.

Graph C – Volume (L) as a function of temperature (K) when the pressure and number of moles are constant.

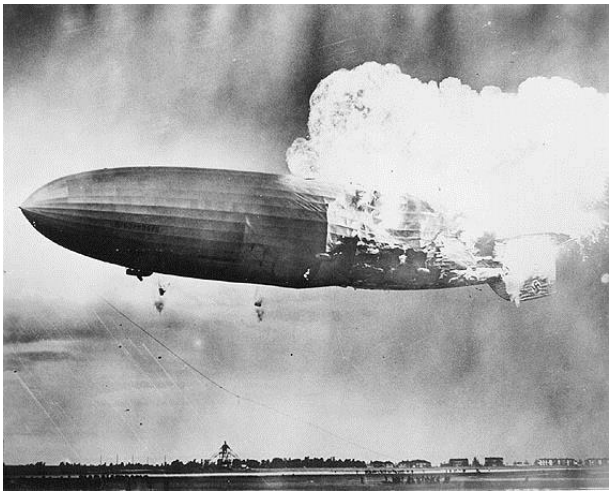
Graph D – Volume (L) as a function of the number of moles of gas when the pressure and temperature are constant.

16 Chlorine gas, Cl_2, must be shipped safely by train from Vancouver to Montreal. It is a very poisonous and corrosive gas.

A tanker car whose volume is 5000.0 L is filled with chlorine gas to a pressure of 250.0 kPa. The temperature of the chlorine gas is 2.0°C.

What is the density of the chlorine gas?

17 The German Zeppelin, the Hindenburg, is most famous for its fiery death. Initially, it was meant to be filled with helium (He). However, because of the costs of helium during the Great Depression, and the politics of pre-war Europe, it was decided to use the less expensive and more readily available hydrogen gas.



The mass of hydrogen gas (H_2) used by the Hindenberg was 18 860 kg.

What mass of helium would have been required to fill the Hindenburg to the same volume under the same conditions of temperature and pressure?

18 Iron (III) oxide, Fe_2O_3, can be converted to iron, Fe, by reacting it with carbon monoxide, CO, according to the following equation:

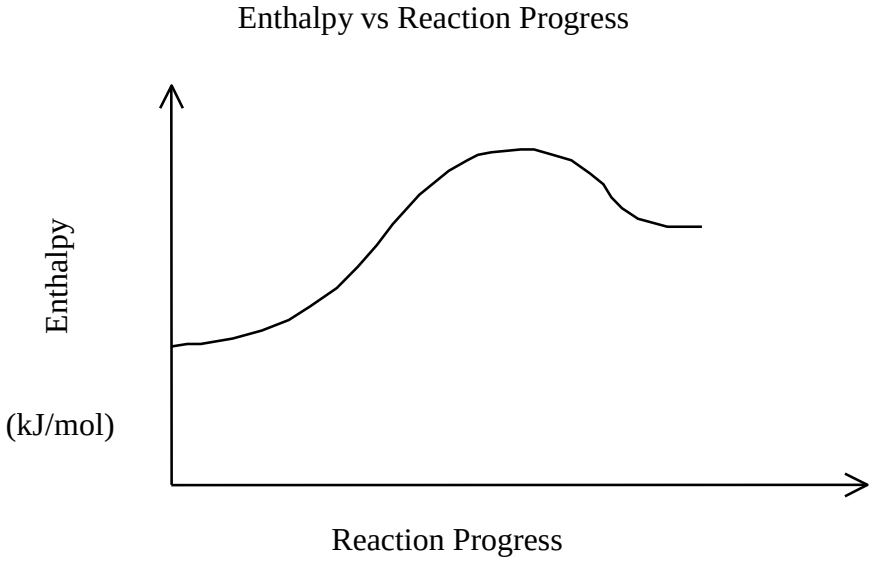
$$Fe_2O_{3(s)} + 3\ CO_{(g)} \rightarrow 2\ Fe_{(s)} + 3\ CO_{2(g)}.$$

The carbon dioxide gas produced is released into the air at a pressure of 98.0 kPa and at a temperature of 120.0°C.

What volume of carbon dioxide, CO_2, produced under these conditions is released when 1.00 kg of iron, Fe, is produced?

Part C	Questions 19, 20, 21, and 22 (Answer **three** questions only.) If you answer all questions in this section, **draw a line through the question that you do not want to have corrected**. If you do not, questions 19, 20 and 21 will be corrected.

19 The change in enthalpy for some processes could be represented by the following graph.



Consider the following changes.

A. The combining of water and carbon dioxide to produce sugar and oxygen in the leaves of plants during photosynthesis.

B. The formation of ice on a lake in winter

For each of the changes listed, state whether the graph above could represent the change. Give a full explanation of your reasoning.

Note Simply identifying the reaction as endothermic or exothermic is **not sufficient**. You must explain what is occurring during the change.

20 Ammonium perchlorate, NH_4ClO_4, is a powerful oxidizing agent. It is used as a solid rocket propellant. In a solid fuel rocket, like those strapped to the space shuttle, oxygen from ammonium perchlorate combines with aluminum to produce aluminum oxide, Al_2O_3, aluminum chloride, $AlCl_3$, water vapor and nitrogen gas.

The equation for the reaction is given below:

$$5\ Al_{(s)} + 3\ NH_4ClO_{4(s)} \rightarrow 2\ Al_2O_{3(s)} + AlCl_{3(s)} + 6\ H_2O_{(g)} + \frac{3}{2}\ N_{2(g)} \qquad \Delta H = -4623\ kJ$$

This reaction produced 1.16×10^5 J of heat.

What mass of ammonium perchlorate was used?

21 Volcanic eruptions discharge sulphur dioxide, SO_2, and hydrogen sulphide, H_2S, gases. These gases react immediately according to the following equation:

$$16\ H_2S_{(g)} + 8\ SO_{2(g)} \rightarrow 3\ S_{8(s)} + 16\ H_2O_{(g)}$$

Consider the equations below.

$$H_{2(g)} + \frac{1}{8}\ S_{8(s)} \rightarrow H_2S_{(g)} \qquad \Delta H = -20.1\ kJ/mol$$

$$\frac{1}{8}\ S_{8(s)} + O_{2(g)} \rightarrow SO_{2(g)} \qquad \Delta H = -296.1\ kJ/mol$$

$$H_{2(g)} + \frac{1}{2}\ O_{2(g)} \rightarrow H_2O_{(l)} \qquad \Delta H = -241.8\ kJ/mol$$

$$H_{2(g)} + \frac{1}{2}\ O_{2(g)} \rightarrow H_2O_{(g)} \qquad \Delta H = -285.8\ kJ/mol$$

What is the heat of reaction, ΔH, for the given reaction?

22 Potassium nitrate, KNO_3, is a highly soluble salt. The molar heat of solution of KNO_3 is +34.9 kJ/mol.

When solid KNO_3 is added to 200.0 mL of water at 18.0°C, the temperature of the resulting solution is 7.0°C.

What mass of solid KNO_3 was added?

Part D	Questions 23, 24 and 25 (Answer **two** questions only.) If you answer all questions in this section, **draw a line through the question that you do not want to have corrected**. If you do not, questions 23 and 24 will be corrected.

23 You parents hosted a dinner party. They opened a large bottle of wine for the guests but very little wine was consumed. They know that wine spoils if it is allowed to react with oxygen.

They have the following choices:

A. Put the original cork into the bottle **or** use a rubber stopper with a valve so that the pressure in the bottle can be lowered.

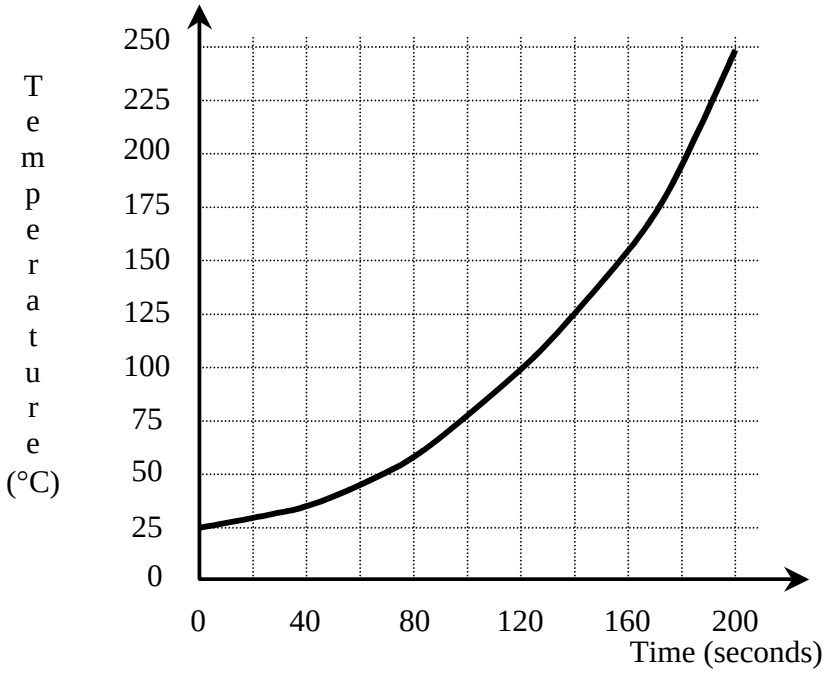
AND

B. Stand the sealed wine bottle upright **or** lay the bottle on its side.

For each of the choices listed above, state which action your parents should take to minimize the rate of oxidation and explain why that action would reduce the rate of oxidation. Your explanation must include references to the collision theory.

24 A camper purchased a camping oven with a butane (C_4H_{10}) burner. * For every 1.0g of butane burned, the temperature of the oven increases by 10.0°C. The maximum temperature of the oven is 250°C. Using the oven's thermometer, the camper records the temperature of the oven every 20 seconds. The results are shown on the graph below.

Oven Temperature as a Function of Time



The combustion of butane is represented by the following equation.

$$2\ C_4H_{10(g)} + 13\ O_{2(g)} \rightarrow 8\ CO_{2(g)} + 10\ H_2O_{(g)}$$

What is the average rate of consumption of oxygen gas (O_2), in grams per second, during the first 120 seconds?

25 Dinitrogen pentoxide, N_2O_5, is a strong oxidizing agent that exists as colourless crystals and is used in the preparation of explosives.

The decomposition of N_2O_5 produces the highly toxic nitrogen dioxide gas, NO_2, according to the following equation:

$$N_2O_{5(s)} \rightarrow 2\ NO_{2(g)} + \frac{1}{2}\ O_{2(g)}$$

The table below shows the amount of N_2O_5 in moles as a function of time for the reaction above.

Amount of N_2O_5 in mol vs. Time	
Time (min)	**N_2O_5 (mol)**
0.0	0.01756
20.0	0.00933
40.0	0.00531
60.0	0.00295
80.0	0.00167
100.0	0.00094
160.0	0.00014

What is the average rate of production of nitrogen dioxide, NO_2, in mol/min, from 40.0 minutes to 100.0 minutes?

Part E	Questions 26, 27, 28, and 29 (Answer **three** questions only.) If you answer all questions in this section, **draw a line through the question that you do not want to have corrected**. If you do not, questions 26, 27 and 28 will be corrected.

26 Consider the following system at equilibrium:

$$2\ NO_{2(g)} + 7\ H_{2(g)} \leftrightarrow 2\ NH_{3(g)} + 4\ H_2O_{(l)} + \text{heat}$$

State how the equilibrium system will shift, if at all, when the following changes occur. Explain each using Le Chatelier's Principle.

A) The temperature of the system is increased.
B) The amount of water is decreased while the pressure of gas remains constant.
C) Hydrogen is removed from the system.
D) The volume of the system is increased.

27 The following chemical system is placed into a 4.0 L sealed container at a constant temperature and allowed to reach equilibrium.

$$UO_{2(s)} + 4\ HF_{(g)} \leftrightarrow UF_{4(g)} + 2\ H_2O_{(g)}$$

Initially 1.0 mole of UO_2 and 1.0 mole of HF are placed into the 4.0 L container and allowed to react. Once equilibrium is established, the UF_4 is found to have a concentration of 0.05 mol/L.

Calculate the equilibrium constant for this equilibrium system.

28 A chemist has just finished testing several samples of acid at 25°C and has filled in a table showing the concentration of each acid, its pH, hydrogen ion concentration, and hydroxide ion concentration. Unfortunately, he spilled some solution on his table and only some of the data is still visible. The information that remains visible is summarized below.

Acid	**Formula**	**Concentration**	**pH**	**$[H^+_{(aq)}]$**	**K_a**
Hypochlorous	$HOCl_{(aq)}$	2.0 mol/L	3.6	2.6×10^{-4} mol/L	3.4×10^{-8} mol/L
Citric	$H_3C_6H_5O_{7(aq)}$	0.12 mol/L	3.70		
Boric	$H_3BO_{3(aq)}$	0.75 mol/L		2.1×10^{-5} mol/L	

The ionization equations are given below.

Hypochlorous acid $HOCl_{(aq)} \rightarrow H^+_{(aq)} + OCl^-_{(aq)}$

Citric acid $H_3C_6H_5O_{7(aq)} \rightarrow H^+_{(aq)} + H_2C_6H_5O_7{}^-_{(aq)}$

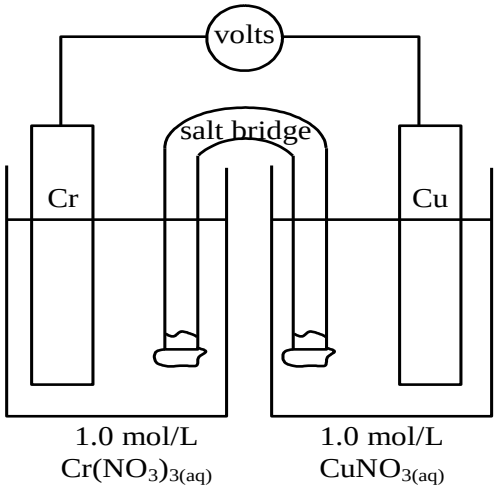
Boric acid $H_3BO_{3(aq)} \rightarrow H^+_{(aq)} + H_2BO_3{}^-_{(aq)}$

Which of these acids is the strongest?

Show all necessary work in the answer booklet.

29 A solid copper, $Cu_{(s)}$, rod is placed into a beaker of 1.0 mol/L $CuNO_{3(aq)}$ solution, and a solid chromium, $Cr_{(s)}$, rod is placed into a beaker of 1.0 mol/L $Cr(NO_3)_{3(aq)}$ solution.

An electrochemical cell is then constructed, as illustrated below.



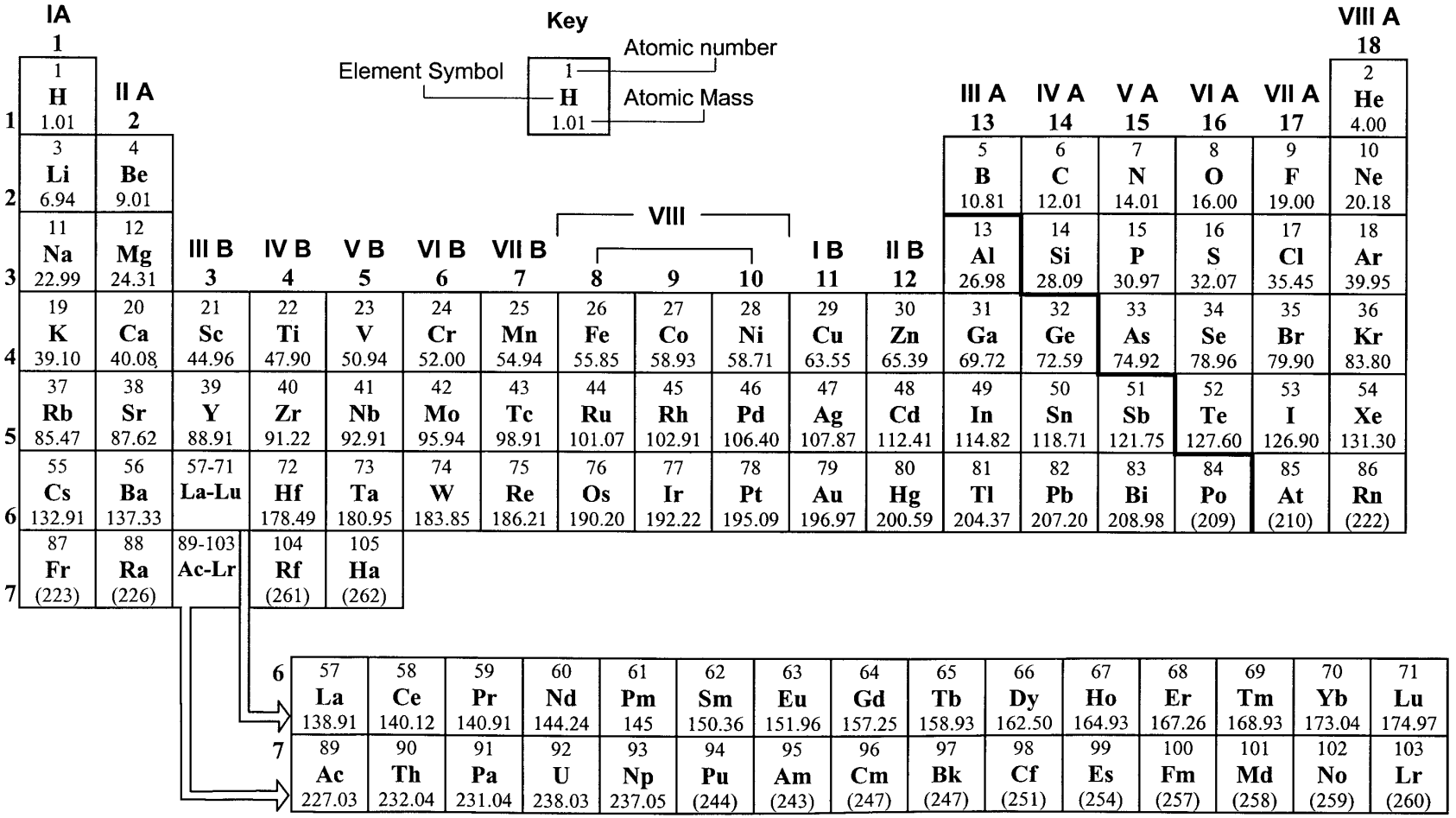
a) What is the balanced reaction?

b) What is the net cell voltage?

c) Based on Le Chatelier's Principle, what can be done to increase the net cell voltage?

d) What purpose does the salt bridge serve?

PERIODIC TABLE OF THE ELEMENTS



	IA 1												III A 13	IV A 14	V A 15	VI A 16	VII A 17	VIII A 18
1	1 H 1.01	II A 2																2 He 4.00
2	3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
3	11 Na 22.99	12 Mg 24.31	III B 3	IV B 4	V B 5	VI B 6	VII B 7	VIII 8	VIII 9	VIII 10	I B 11	II B 12	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.71	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc 98.91	44 Ru 101.07	45 Rh 102.91	46 Pd 106.40	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 131.30
6	55 Cs 132.91	56 Ba 137.33	57-71 La-Lu	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.20	77 Ir 192.22	78 Pt 195.09	79 Au 196.97	80 Hg 200.59	81 Tl 204.37	82 Pb 207.20	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra (226)	89-103 Ac-Lr	104 Rf (261)	105 Ha (262)													

6	57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm 145	62 Sm 150.36	63 Eu 151.96	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
7	89 Ac 227.03	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 (254)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)

FORMULAS

$$Q = mc\Delta T$$

$$PV = n\,RT$$

$$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$$

PHYSICAL CONSTANTS

SYMBOL	NAME	VALUE
c_{H_2O}	Specific heat capacity of water	4190 J/(kg•°C) or 4.19 J/(g•°C)
ρ_{H_2O}	Density of water	1.00 g/mL
R	Molar gas constant	8.31 kPa • L/(mol•K)

Standard Reduction Potentials

ION CONCENTRATION of 1 mol/L at 25°C and 101.3 kPa.

Reduction Half-reaction				Reduction Potential (V)
$F_2(g)$	$+ 2e^-$	$\rightarrow$	$2F^-(aq)$	E° = + 2.87
$Au^{3+}(aq)$	$+ 3e^-$	$\rightarrow$	$Au(s)$	E° = + 1.50
$Cl_2(g)$	$+ 2e^-$	$\rightarrow$	$2Cl^-(aq)$	E° = + 1.36
$Br_2(aq)$	$+ 2e^-$	$\rightarrow$	$2Br^-(aq)$	E° =+ 1.09
$Br_2(l)$	$+ 2e^-$	$\rightarrow$	$2Br^-(aq)$	E° =+ 1.07
$Ag^+(aq)$	$+ e^-$	$\rightarrow$	$Ag(s)$	E° = + 0.80
$Hg^{2+}(aq)$	$+ 2e^-$	$\rightarrow$	$Hg(l)$	E° = + 0.78
$Fe^{3+}(aq)$	$+ e^-$	$\rightarrow$	$Fe^{2+}(aq)$	E° = + 0.77
$I_2(s)$	$+ 2e^-$	$\rightarrow$	$2I^-(aq)$	E° = + 0.53
$Cu^+(aq)$	$+ e^-$	$\rightarrow$	$Cu(s)$	E° = + 0.52
$Cu^{2+}(aq)$	$+ 2e^-$	$\rightarrow$	$Cu(s)$	E° = + 0.34
$2H^+(aq)$	$+ 2e^-$	$\rightarrow$	$H_2(g)$	E° = + 0.00
$Pb^{2+}(aq)$	$+ 2e^-$	$\rightarrow$	$Pb(s)$	E° = - 0.13
$Sn^{2+}(aq)$	$+ 2e^-$	$\rightarrow$	$Sn(s)$	E° = - 0.14
$Ni^{2+}(aq)$	$+ 2e^-$	$\rightarrow$	$Ni(s)$	E° = - 0.26
$Co^{2+}(aq)$	$+ 2e^-$	$\rightarrow$	$Co(s)$	E° = - 0.28
$Fe^{2+}(aq)$	$+ 2e^-$	$\rightarrow$	$Fe(s)$	E° = - 0.44
$Cr^{3+}(aq)$	$+ 3e^-$	$\rightarrow$	$Cr(s)$	E° = - 0.74
$Zn^{2+}(aq)$	$+ 2e^-$	$\rightarrow$	$Zn(s)$	E° = - 0.76
$Cr^{2+}(aq)$	$+ 2e^-$	$\rightarrow$	$Cr(s)$	E° = - 0.91
$Mn^{2+}(aq)$	$+ 2e^-$	$\rightarrow$	$Mn(s)$	E° = - 1.18
$Al^{3+}(aq)$	$+ 3e^-$	$\rightarrow$	$Al(s)$	E° = - 1.66
$Be^{2+}(aq)$	$+ 2e^-$	$\rightarrow$	$Be(s)$	E° = - 1.85
$Mg^{2+}(aq)$	$+ 2e^-$	$\rightarrow$	$Mg(s)$	E° = - 2.37
$Na^+(aq)$	$+ e^-$	$\rightarrow$	$Na(s)$	E° = - 2.71
$Ca^{2+}(aq)$	$+ 2e^-$	$\rightarrow$	$Ca(s)$	E° = - 2.87
$Sr^{2+}(aq)$	$+ 2e^-$	$\rightarrow$	$Sr(s)$	E° = - 2.89
$Ba^{2+}(aq)$	$+ 2e^-$	$\rightarrow$	$Ba(s)$	E° = - 2.91
$Cs^+(aq)$	$+ e^-$	$\rightarrow$	$Cs(s)$	E° = - 2.92
$K^+(aq)$	$+ e^-$	$\rightarrow$	$K(s)$	E° = - 2.93
$Rb^+(aq)$	$+ e^-$	$\rightarrow$	$Rb(s)$	E° = - 2.98
$Li^+(aq)$	$+ e^-$	$\rightarrow$	$Li(s)$	E° = - 3.04

Lester B. Pearson School Board

Commission scolaire Lester-B.-Pearson

JUNE 2010

CHEMISTRY 534

551-534

-EXAMINATION-

Answer Booklet

NAME
CLASS

Mathematics and Science & Technology Committee

Part A **Questions 1 to 14**

Blacken the letter that corresponds to your answer.

Each question is worth four marks.

1 [A] [B] [C] [D]

2 [A] [B] [C] [D]

3 [A] [B] [C] [D]

4 [A] [B] [C] [D]

5 [A] [B] [C] [D]

6 [A] [B] [C] [D]

7 [A] [B] [C] [D]

8 [A] [B] [C] [D]

9 [A] [B] [C] [D]

10 [A] [B] [C] [D]

11 [A] [B] [C] [D]

12 [A] [B] [C] [D]

13 [A] [B] [C] [D]

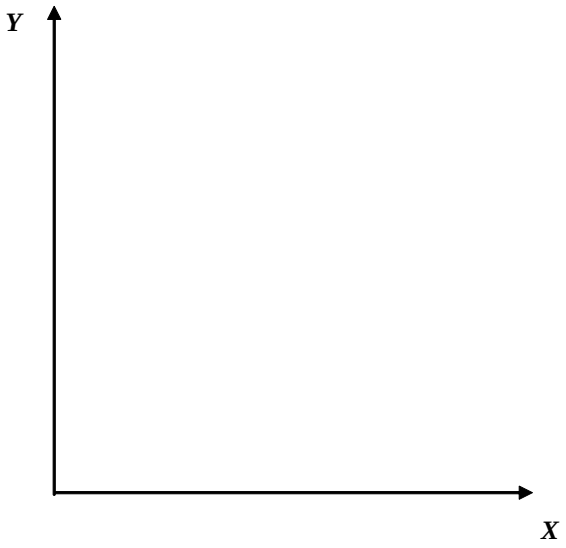
14 [A] [B] [C] [D]

Part B Questions 15, 16, 17 and 18

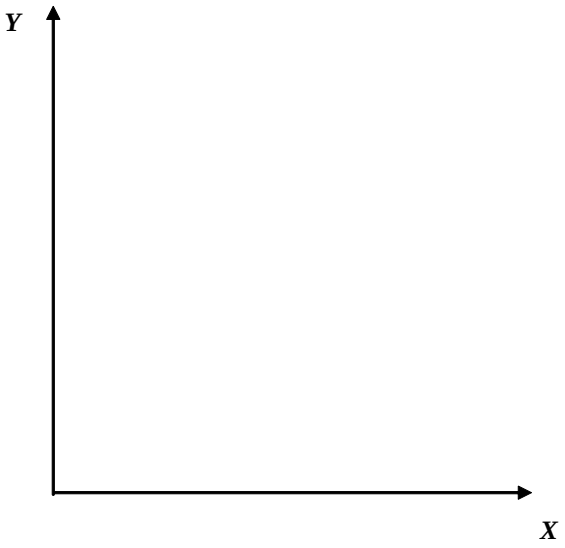
If you answer all questions in this section, **draw a line through the question that you do not want to have corrected**. If you do not, questions 15, 16 and 17 will be corrected.

15

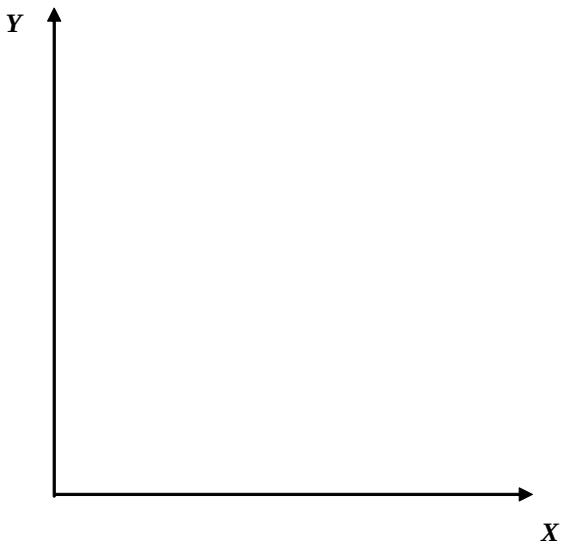
Graph A **Pressure vs Temperature**



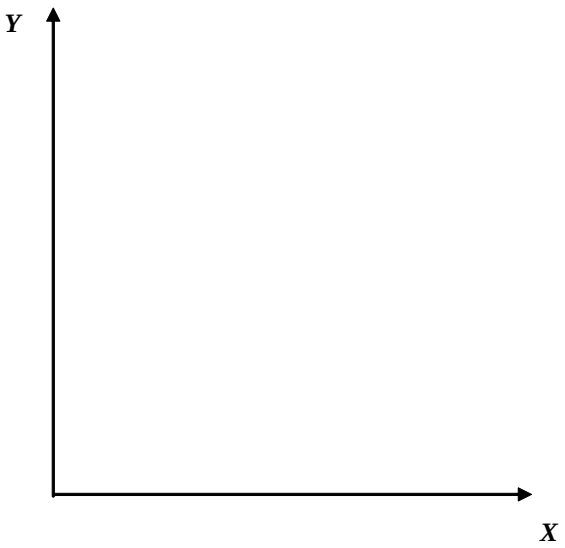
Graph B **Pressure vs Volume**



Graph C **Volume vs Temperature**



Graph D **Volume vs Number of Moles**



4	3	2	1	0

16

SHOW ALL YOUR WORK

(Include units of measurement.)

Answer: The density of the chlorine gas is _____.

4	3	2	1	0

17

SHOW ALL YOUR WORK

(Include units of measurement.)

Answer: The mass of helium, $He_{(g)}$, required to fill the Hindenburg at the same temperature and pressure is _____.

4	3	2	1	0

18

SHOW ALL YOUR WORK

(Include units of measurement.)

Answer: The volume of CO_2 gas released for each kilogram of iron produced is_____.

4	3	2	1	0

Part C Questions 19, 20, 21 and 22.

If you answer all questions in this section, **draw a line through the question that you do not want to have corrected**. If you do not, questions 19, 20 and 21 will be corrected.

19

SHOW ALL YOUR WORK (Simply identifying the change as endothermic or exothermic is not an appropriate explanation.)

A. The graph given _____ represent this change.
(could, could not)

Explanation: _____

B. The graph given _____ represent this change.
(could, could not)

Explanation: _____

4	3	2	1	0

20

SHOW ALL YOUR WORK

(Include units of measurement.)

Answer: _____ of $NH_4ClO_{4(s)}$ were used.

4	3	2	1	0

21

SHOW ALL YOUR WORK

(Include units of measurement.)

Answer: The heat reaction, ΔH, is _____.

4	3	2	1	0

22

SHOW ALL YOUR WORK

(Include units of measurement.)

Answer: The mass of solid of KNO_3 that was added is _____.

4	3	2	1	0

Part D Questions 23, 24 and 25.

If you answer all questions in this section, **draw a line through the question that you do not want to have corrected**. If you do not, questions 23 and 24 will be corrected.

23

SHOW ALL YOUR WORK

A. Required Action: _____

Explanation: _____

B. Required Action: _____

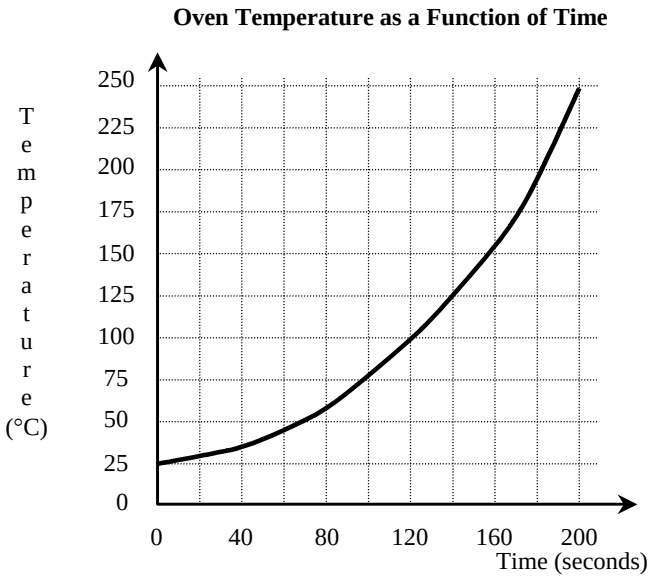
Explanation: _____

4	3	2	1	0

24

SHOW ALL YOUR WORK

$$2\ C_4H_{10(g)} + 13\ O_{2(g)} \rightarrow 8\ CO_{2(g)} + 10\ H_2O_{(g)}$$



(Include units of measurement.)

Answer: The average rate of consumption of oxygen gas, O_2, in the first 120 seconds is _____.

4	3	2	1	0

25

SHOW ALL YOUR WORK

Amount of N_2O_5 in mol vs. Time	
Time (min)	**N_2O_5 (mol)**
0.0	0.01756
20.0	0.00933
40.0	0.00531
60.0	0.00295
80.0	0.00167
100.0	0.00094
160.0	0.00014

(Include units of measurement.)

Answer: The average rate of production of nitrogen dioxide, NO_2, is _____.

4	3	2	1	0

Part E Questions 26, 27, 28 and 29.

If you answer all questions in this section, **draw a line through the question that you do not want to have corrected**. If you do not, questions 26, 27 and 28 will be corrected.

26

SHOW ALL YOUR WORK

A)

B)

C)

D)

4	3	2	1	0

27

SHOW ALL YOUR WORK

$$UO_{2(s)} + 4\,HF_{(g)} \leftrightarrow UF_{4(g)} + 2\,H_2O_{(g)}$$

(Include units of measurement.)

Answer: The equilibrium constant is _____.

4	3	2	1	0

28

SHOW ALL YOUR WORK

Acid	**Formula**	**Concentration**	**pH**	**$[H^+_{(aq)}]$**	**K_a**
Hypochlorous	$HOCl_{(aq)}$	2.0 mol/L	3.6	2.6×10^{-4} mol/L	3.4×10^{-8} mol/L
Citric	$H_3C_6H_5O_{7(aq)}$	0.12 mol/L	3.7		
Boric	$H_3BO_{3(aq)}$	0.75 mol/L		2.1×10^{-5} mol/L	

Calculations for citric acid

Calculations for boric acid

Answer: The strongest acid is _____.

4	3	2	1	0

29

SHOW ALL YOUR WORK

a)

The balanced reaction: _____

b)

The net cell voltage: _____

c) _____

_____

d) _____

_____

4	3	2	1	0