Lester B. Pearson School Board

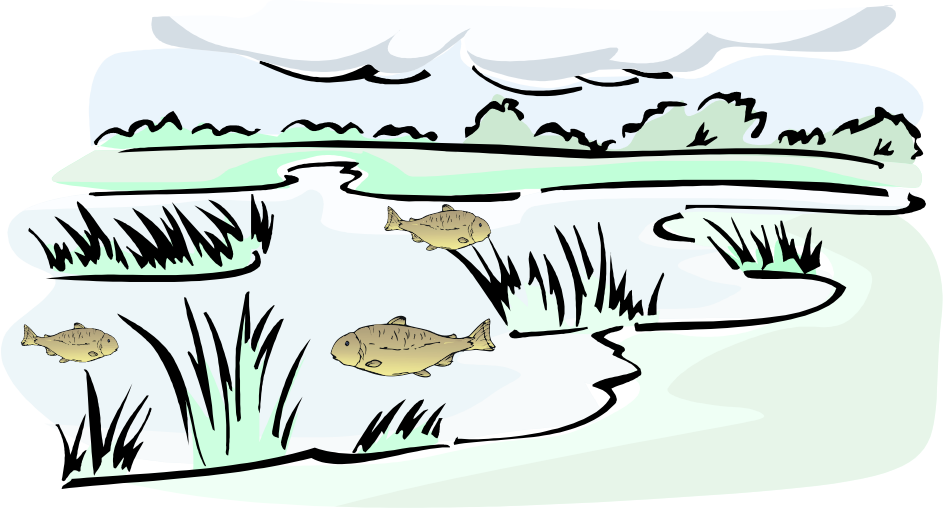
Commission scolaire Lester-B.-Pearson

JUNE 2012

CHEMISTRY

Secondary 5
551-504

Theory Examination



Question Booklet

Time: 3 hours

GRICS BIM

INSTRUCTIONS

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

2. You are permitted to use drawing instruments and a scientific calculator without a graphic display.

3. You may refer to the Periodic Table of the Elements and lists of Formulas and Quantities included in the Appendices to this ***Question Booklet***. The use of any other reference material is strictly forbidden.

4. Write your answers in the ***Answer Booklet***.

5. Show all your work needed to solve the problem: data given, explanations, formulas and calculations. 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. The correct unit of measurement must be included in the answer.

6. The rules of significant figures should be applied to all final statements. A total of 3 marks has been allocated for the consistent use of significant figures throughout Questions 8, 9, 10, 14, 16, 17, 18 and 19 of this examination.

7. This examination is made up of 19 questions and is worth 85 marks.

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

TIME: 3 hours

Part A
Multiple Choice Questions

Questions 1 to 7

Answer all questions in the ***Answer Booklet***.

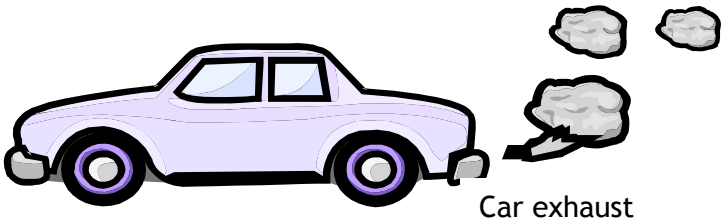
Shade the letter that corresponds to your answer.

Each question is worth 4 marks.

Question 1

The following gases are all products of the internal combustion engine.

CO CO_2 NO H_2O



Car exhaust

Which one of following combinations ranks these gases in INCREASING order of diffusion rate?

A) CO, NO, CO_2, H_2O

B) CO_2, NO, CO, H_2O

C) H_2O, CO, NO, CO_2

D) H_2O, NO, CO, CO_2

Question 2

Four teams of chemistry students were investigating the relationship between the pressure, volume and temperature of gases. The tables below represent the data collected by each team.

Which team's table best represents the effect changing volume has on pressure, if temperature is held constant?

A) **Team A**

V (mL)	140.0	134.0	132.0	126.0	122.5	117.6
P (kPa)	107.1	111.9	113.6	119.0	122.4	127.5

B) **Team B**

V (mL)	60.0	70.0	80.0	90.0	100.0	110.0
P (kPa)	125.6	107.1	89.2	71.1	53.0	35.4

C) **Team C**

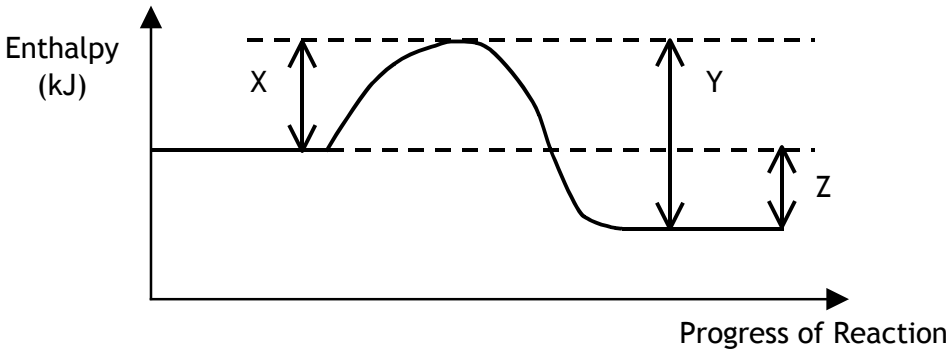
V (mL)	140.0	135.0	132.5	125.0	122.5	117.5
P (kPa)	200.0	185.9	179.2	159.4	153.15	140.9

D) **Team D**

V (mL)	87.8	88.0	88.4	88.8	89	89.3
P (kPa)	692.0	609.1	438.4	261.2	170.0	29.9

Question 3

The enthalpy diagram below represents a reversible reaction.



Which of the following statements concerning the diagram above is correct?

A) Y represents the activation energy of the reverse reaction, which is exothermic.

B) X represents the activation energy of the forward reaction, which is exothermic.

C) Z represents the activation energy of the reverse reaction, which is endothermic.

D) Y represents the activation energy of the forward reaction, which is endothermic.

Question 4

Chef Avi is heating water on a natural gas stove. To heat 6.25 L of water, 0.475 moles of natural gas (CH_4) are burned. (Assume no heat loss.)

What is the molar heat of combustion of natural gas if the water temperature rises 45.7°C?

A) 2.52×10^3 kJ/mol

B) 1.20×10^3 kJ/mol

C) 5.68×10^2 kJ/mol

D) 9.08×10^1 kJ/mol

Question 5

In a chemical reaction, A decomposes to produce B and C at a certain rate:

$$A \rightarrow B + C$$

It is observed that when the concentration of A is doubled, the initial reaction rate is doubled.

Which of the following is the correct rate law expression for this reaction?

A) $r = 2k[A]$

B) $r = k[A]^2$

C) $r = k[A]$

D) $r = k[A]^0$

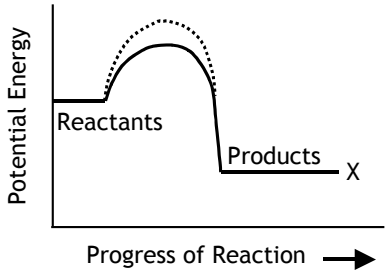
Question 6

Many chemical reactions that occur in the human body are affected by enzymes which act as catalysts. One in particular involves an enzyme that allows glucose to be oxidized at normal body temperatures.

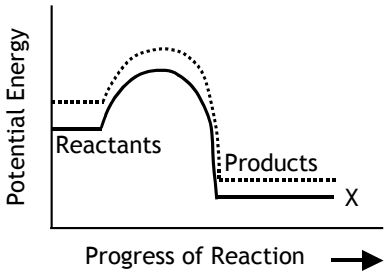
In the graphs below, pathway X is a solid line representing the uncatalyzed reaction. The dotted line shows the catalyzed reaction.

Which graph best illustrates the changes in a reaction when a catalyst is used?

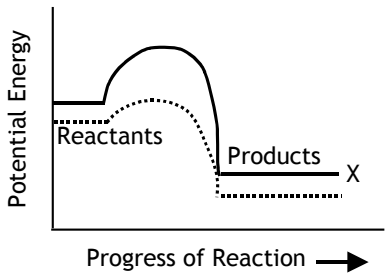
A)



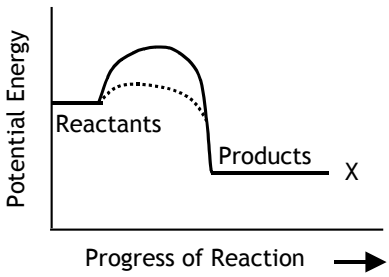
C)



B)



D)



Legend
Catalyzed Reaction
Uncatalyzed Reaction, pathway X

Question 7

Ammonia (NH_3) is manufactured through the Haber process. In this reaction, nitrogen (N_2) gas is combined with hydrogen (H_2) gas at 400°C and 202 kPa. The following reaction occurs:

$$N_{2(g)} + 3\ H_{2(g)} \rightleftharpoons 2\ NH_{3(g)} \quad \Delta H = -92\ kJ/mol$$

A leak occurred which resulted in a decrease in pressure in the system.

Which of the following statements is TRUE?

A) The products would be favoured.

B) The production of ammonia would decrease.

C) ΔH of the reaction would increase.

D) The concentration of nitrogen gas would decrease.

Part B
Constructed Response Questions

Questions 8 to 15

Answer all these questions in the ***Answer Booklet***.

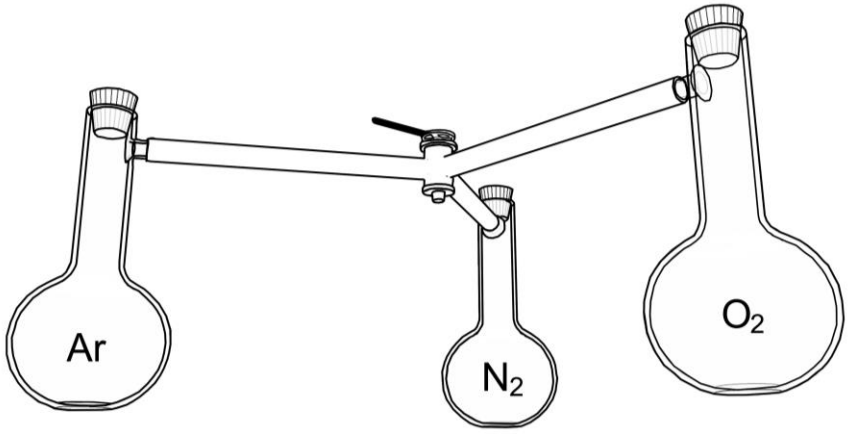
Show all the work needed to solve the problem.

The consistent use of significant figures will be evaluated for for Questions 8, 9, 10 and14.

Question 8

Earth's atmosphere contains a mixture of many gases, of which the principle components are: nitrogen (78%), oxygen (21%), argon and other trace gases (1%).

To recreate our atmosphere, a scientist connects three one-litre flasks containing the gases indicated in the diagram below. The flasks are connected to each other by a stopcock. In order to verify whether this gas mixture corresponds to earth's atmosphere, the scientist must determine the percentage (mole fraction) of oxygen (O_2) in this mixture.



- Flask one contains argon (Ar) gas at 75 kPa.
- Flask two contains nitrogen (N_2) gas at 150 kPa.
- Flask three contains oxygen (O_2) at 106 kPa.

The valve is opened, allowing all three gases to mix.

Does this gas mixture correspond to the Earth's atmosphere?

Explain your answer.

Question 9

An oceanographer would like to identify the gases which are emitted from hydrothermal vents found on the ocean floor.

He collects samples, separates them into component gases and identifies the following properties for one of the unknown gases:

Unknown Gas Data Table

Mass of empty container	4.30 g
Mass of empty container + unknown gas	6.06 g
Volume of container	1225 mL
Temperature	18.0 °C
Pressure	102 kPa

He believes that the gas could be one of the following:

Carbon monoxide (CO), hydrogen (H_2), methane (CH_4), or hydrogen sulphide (H_2S).

What is the unknown gas?

Question 10

Carbon tetrachloride (CCl_4), which is used in refrigeration, can be formed by reacting chlorine (Cl_2) with methane (CH_4).

$$CH_{4(g)} + 2\ Cl_{2(g)} \rightleftharpoons CCl_{4(l)} + 2\ H_{2(g)}$$

Bond Enthalpies

Bond	Energy (kJ/mol)
H–H	436
H–O	460
H–F	570
H–Cl	432
C–H	413
C–C	347
C=C	607
C–O	358
O=O	498
Cl–Cl	243
C–Cl	397

Using bond enthalpies, determine the heat of reaction for the formation of carbon tetrachloride.

Question 11

In Québec, the production of iron is an important industry. Iron can be produced according to the following reaction:

$$Fe_2O_3 + 3\ CO \rightarrow 2\ Fe + 3\ C0_2$$

The reaction begins with 40 kJ of potential energy and requires 10 kJ of activation energy. The activation energy of the reverse reaction is 35 kJ.

Sketch the potential energy diagram (in your Answer Booklet) for this reaction and identify ΔH.

Question 12

Danielle works as a waitress in a restaurant. She is asked to store an open bottle of wine.

The bottle of wine contains ethanol (C2H5OH). If the bottle is left open, the ethanol changes into acetic acid (CH3COOH) which causes the wine to taste sour.

The following reaction illustrates this change:

$$C_2H_5OH_{(l)} + O_{2(g)} \rightarrow CH_3COOH_{(l)} + H_2O_{(l)}$$

In order to save the wine that is left in the opened bottle, Danielle seals the bottle and:

- places it upright (not on its side)
- keeps it in a cool place.

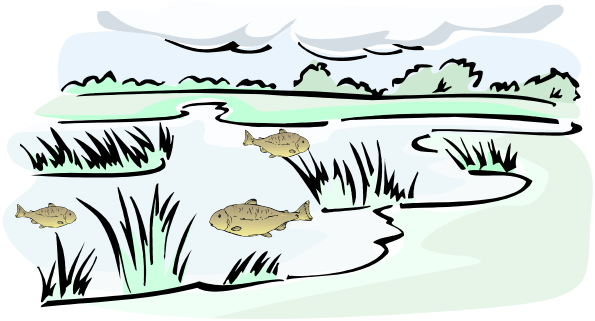
Using collision theory, explain how these two factors slow the reaction.

Question 13

Excess levels of carbon dioxide (CO_2) in water are harmful to fish. Therefore, testing for carbon dioxide levels in water in which fish are raised is important.

Carbon dioxide in water forms carbonic acid (H_2CO_3) according to the following reaction:

$$CO_{2(g)} + H_2O_{(l)} \rightarrow H_2CO_{3(aq)}$$



The pH of a water sample is found to be 6.2.

What is the hydroxide ion [OH^-] concentration in the water sample?

Question 14

Strontium fluoride (SrF_2) is added to toothpaste in order to strengthen tooth enamel and reduce temperature sensitivity.

The equation below represents the solubility equilibrium for strontium fluoride.

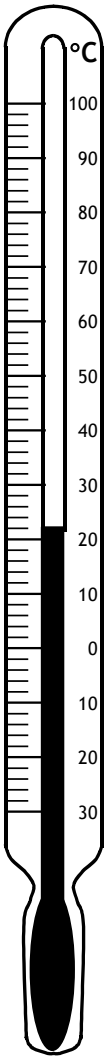
$$SrF_{2(s)} \rightleftharpoons Sr_2^{+}{}_{(aq)} + 2F^-_{(aq)}$$

The K_{sp} of strontium fluoride is 4.33×10^{-9} at 25 °C.

What is the fluoride ion concentration in a saturated solution of strontium fluoride at 25 °C?

Question 15

Below is a diagram of a thermometer.



What is the temperature as measured by the thermometer?
Observe the conventions regarding significant figures and give the uncertainty of the measurement.

Part C
Extended Constructed Response Questions

Questions 16 to 19

Answer all these questions in the ***Answer Booklet***.

Show all the work needed to solve the problem.

The consistent use of significant figures will be evaluated for all questions in Part C.

Each question is worth 6 marks.

Question 16

Photosynthesis is the process by which plants use carbon dioxide (CO_2) and water (H_2O) to produce glucose ($C_6H_{12}O_6$) and oxygen (O_2). The following balanced equation represents this reaction:

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

A plant produced 100.0 mL of glucose solution. The concentration of the glucose solution is 0.83 mol/L.

What volume of carbon dioxide at SATP did this plant absorb?

Question 17

Ammonia ($NH_{3)}$ in the soil reacts continuously with oxygen (O_2) to produce nitrogen dioxide (NO_2) and water, as seen in the balanced chemical equation below.

$$NH_{3(g)} + \frac{7}{4}\ O_{2(g)} \rightarrow NO_{2(g)} + \frac{3}{2}\ H_2O_{(l)}$$

During this process a temperature change occurs.

You have collected the following data:

Equation one: $\frac{1}{2}\ N_{2(g)} + O_{2(g)} + 33.9\ kJ \rightarrow NO_{2(g)}$

Equation two: $\frac{1}{2}\ N_{2(g)} + \frac{3}{2}\ H_{2(g)} \rightarrow NH_{3(g)} + 46.2\ kJ$

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

Determine the enthalpy change, ΔH, for the reaction of ammonia and oxygen shown above.

Question 18

Glucose ($C_6H_{12}O_6$) is converted to energy for use in the body. This a complex process that requires many steps to occur.

The following is the overall reaction:

$$C_6H_{12}O_{6(aq)} + 6\ O_{2(g)} \rightarrow 6\ CO_{2(g)} + 6\ H_2O_{(l)} + 2870\ kJ$$

In reality, this reaction takes place in cells a few molecules at a time. A scientist is studying the reaction in the laboratory by dissolving 108.0 g of glucose in 150.0 mL of water and bubbling oxygen through the solution. It takes 10.0 minutes to oxidize all the glucose.

a) What is the average rate of production of carbon dioxide (CO_2) in mol/s?

b) The scientist would like to predict the rate of production of CO_2 for different concentrations of glucose.

What information must he gather in order to be able to predict the reaction rate? Explain your answer.

Question 19

Acidulants are acids that are added to foods to slow bacterial growth. The stronger the acid, the more effective it is in slowing bacterial growth.

A food scientist is verifying the strength of two acids to help determine which would be the most effective in slowing bacterial growth.

Acid 1: Acetic Acid

A solution of *acetic acid,* $HC_2H_3O_2$, is prepared by dissolving 0.90 grams of acetic acid in enough water to make 150 mL of solution. The solution is allowed to reach equilibrium as shown by the chemical equation below:

$$HC_2H_3O_{2(aq)} \rightarrow H^+_{(aq)} + C_2H_3O_2^-{}_{(aq)}$$

The pH of the solution at equilibrium is 2.9.

Acid 2: Lactic Acid

A solution of *lactic acid*, $HCH_3CH(OH)CO_2$, with a concentration of 1.1×10^{-2} mol/L is allowed to reach equilibrium, as shown by the chemical equation below:

$$HCH_3CH(OH)CO_{2(aq)} \rightarrow H^+_{(aq)} + CH_3CH(OH)CO_2^-{}_{(aq)}$$

The concentration of hydrogen ions at equilibrium is 1.2×10^{-3} mol/L.

Which of the two acids would be the most effective for slowing bacterial growth?

Explain your answer.

Appropriate use of significant figures for Questions 8, 9, 10, 14, 16, 17, 18 and 19

Appendix 1

PERIODIC TABLE OF THE ELEMENTS

Key: Element Symbol — H; Atomic number — 1; Atomic Mass — 1.01

	IA 1	II A 2	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	III A 13	IV A 14	V A 15	VI A 16	VII A 17	VIII A 18
1	1 **H** 1.01																	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											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)

Appendix 2

FORMULAS

$$Q = mc\Delta T$$

$$PV = n\,RT$$

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

$$P_T = P_A + P_B + P_C + \ldots$$

$$P_A = P_T\,\frac{n_A}{n_T}$$

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)
SATP	Standard ambient temperature and pressure	Temperature: 25.0°C
		Pressure: 101.3 kPa