Dell Rae
Answer.

Lester B. Pearson
School Board

Commission scolaire
Lester-B.-Pearson

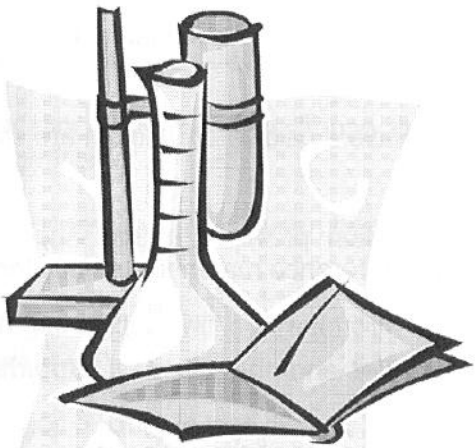
JUNE 2015

CHEMISTRY

Secondary 5

551-504

Theory Examination



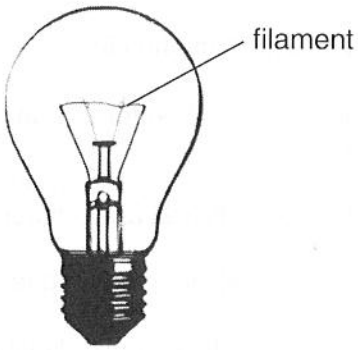
Question Booklet

Part A

Multiple-Choice Questions 1 to 10

Answer all questions in your ***Student Booklet***.

1. Incandescent light bulbs contain a thin metal filament that heats up and releases light energy when electricity is passed through it. The light bulb is filled with a mixture of 93% argon gas and 7% nitrogen gas.



non-reactive

Why is the argon-nitrogen gas mixture used to fill the light bulb instead of air?

don't care

Noble

A) The argon-nitrogen gas mixture is less dense than air, making the bulb lighter in mass than if it was air filled.

inert

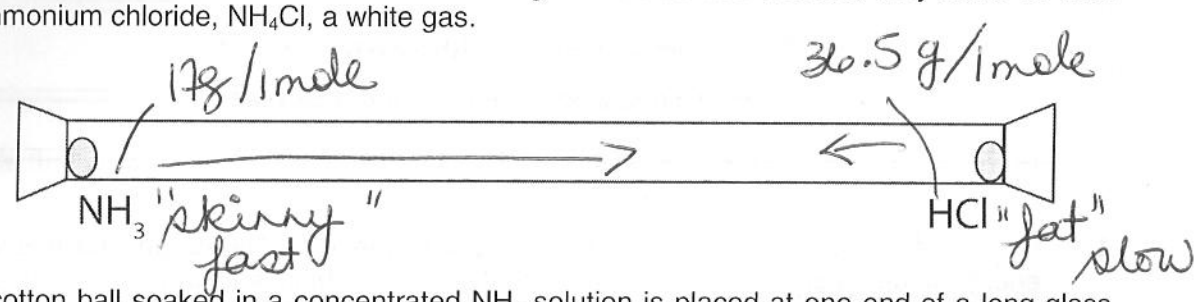
B) The argon gas and nitrogen gas react when heated to form a compound that protects the metal filament.

C) The argon-nitrogen gas mixture will not react with the metal filament in the light bulb, but oxygen in the air would.

D) The argon-nitrogen gas mixture is less likely to diffuse out of the bulb.

not a consideration

2. When ammonia, NH_3, and hydrochloric acid, HCl, solutions evaporate, the gases formed are colourless. However when these two gases come into contact, they react to form ammonium chloride, NH_4Cl, a white gas.



A cotton ball soaked in a concentrated NH_3 solution is placed at one end of a long glass tube and a cotton ball soaked in a concentrated HCl solution is placed at the other end of a long glass tube. The tube is then sealed.

What will be observed in the tube as the NH_3 and HCl solutions evaporate?

A) A white ring of NH_4Cl gas will first form at the half-way point between the ends of the tube.

B) A white ring of NH_4Cl gas will first form closer to the HCl end of the tube.

C) A white ring of NH_4Cl gas will first form closer to the NH_3 end of the tube.

D) A white ring of NH_4Cl gas will immediately fill the entire tube.

3. Jacques Charles was an inventor, scientist, and balloonist. Charles, along with the Robert brothers, launched the world's first hydrogen filled balloon on August 27, 1783. Charles took days to fill the balloon with hydrogen gas, H_2, to a volume of 3.5×10^4 L. Once filled, the temperature was 21 °C and the atmospheric pressure was 100 kPa.

What was the density of the gas in the balloon?

A) 4.0×10^{-8} g/L

B) 0.041 g/L

C) 0.083 g/L

D) 1.1 g/L

$T = 21°C + 273$
$= 294\,K$

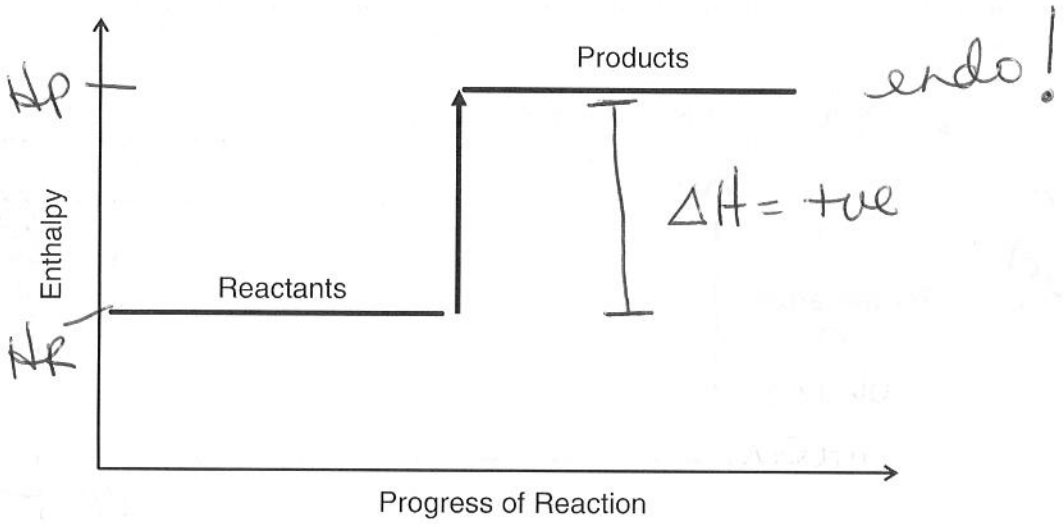
$PV = nRT$

$\frac{PV}{P} = \frac{m}{mm} \frac{RT}{} \times \frac{mm}{RT}$

$\frac{Pmm}{RT} = \frac{m\,(g)}{V\,(L)} = d.$

$= \frac{(100)(2)}{(8.314)(294)} =$

4. The energy changes during a chemical reaction are represented on the diagram below.



Which of the changes below could be represented by this diagram??

1) $H_2O_{(g)} + C_{(s)} \rightarrow H_{2(g)} + CO_{(g)}$ $\Delta H = 131.8$ kJ/mol

2) $H_{2(g)} + 1/2\ O_{2(g)} \rightarrow H_2O_{(l)}$ $\Delta H = -285.9$ kJ/mol

3) $1/2\ N_{2(g)} + O_{2(g)} + 34\ kJ \rightarrow NO_{2(g)}$

4) $C_3H_{8(g)} + 5\ O_{2(g)} \rightarrow 3\ CO_{2(g)} + 4\ H_2O_{(g)} + 2043.9$ kJ

A) 1 and 3

B) 1 and 4

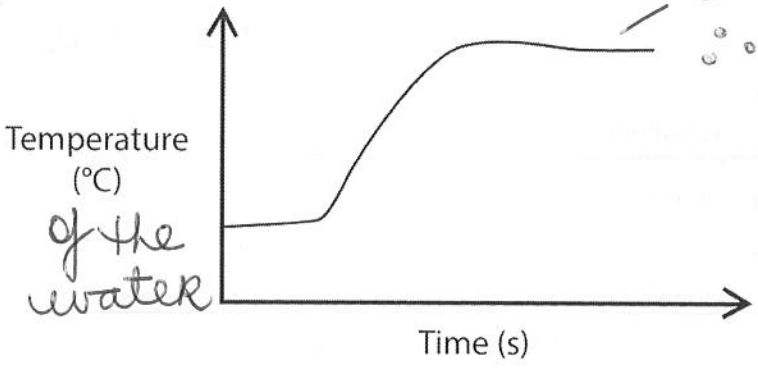
C) 2 and 3

D) 2 and 4

5. Sunil performed an experiment in which he dissolved a salt in water in a calorimeter. He recorded measurements of the temperature of the water in the calorimeter over time for the duration of the experiment and his results have been graphed below.

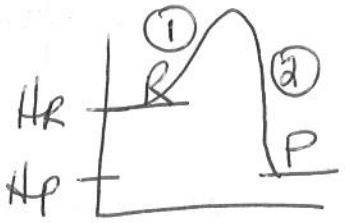
not an enthalpy graph

Dissolving a Salt in a Calorimeter



of the water

water T increased
∴ the water absorbed energy from the dissolution process
∴ dissolution was exo



Consider the following statements:

1) The dissolving of the salt is an exothermic process. ✓
2) The enthalpy of the products is greater than the enthalpy of the reactants. ✗
3) If more water is used, the temperature increase will be greater. ✗
4) The amount of energy required for the dissolution to occur was less than the amount of energy released into the solution. (2) (1)

Which of the statements are true for this experiment?

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

6. The reaction of silver, Ag, with nitric acid, $HNO_{3(aq)}$, is being used to study the rate of reactions.

$$2\ Ag_{(s)} + 2\ HNO_{3(aq)} \rightarrow 2\ AgNO_{3(aq)} + H_{2(g)}$$

From 10 s after the reaction started to 35 s after the reaction started, 0.06 moles of H_2 gas were produced.

What was the average rate of consumption of silver for this time period?

A) 1.7×10^{-3} mol/s

B) 2.4×10^{-3} mol/s

C) 3.4×10^{-3} mol/s

D) 4.8×10^{-3} mol/s

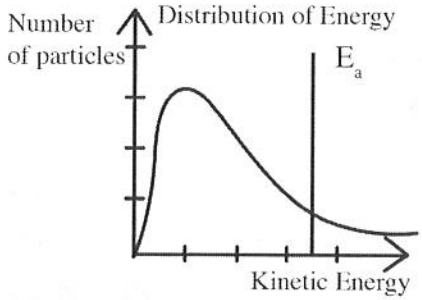
$$\frac{0.06\ mol\ H_2}{(35\ s - 10\ s)} \times \frac{2\ mol\ Ag}{1\ mol\ H_2} = \frac{0.0048\ mol\ Ag}{5}$$

7. In order to reduce air pollution, automobiles are equipped with a device called a catalytic converter that reduces emissions of carbon monoxide as well as other harmful compounds found in car exhaust.

The car exhaust is forced through a screen coated with the metal catalysts. As a result, the reaction below that converts carbon monoxide gas into carbon dioxide gas is catalyzed:

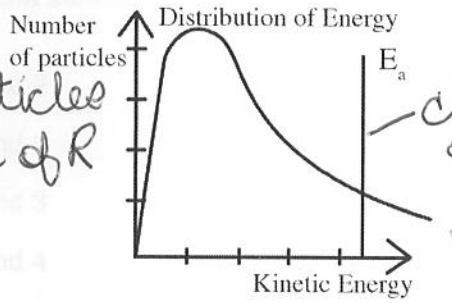
$$2\ CO_{(g)} + O_{2(g)} \rightarrow 2\ CO_{2(g)}$$

The graph below corresponds to the reaction above during a cold start (before the engine is warmed up) and before the exhaust passes through the catalytic converter.

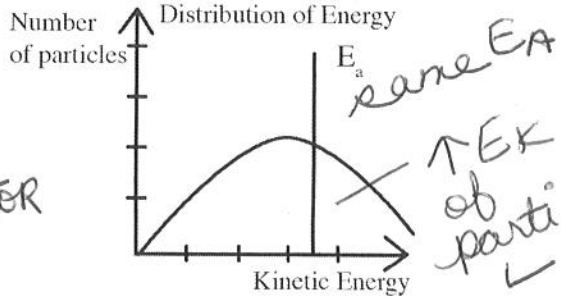


Which of the graphs below best represents the energy distribution curve for the reaction when the car is running at a higher temperature and when the exhaust passes through the catalysts?

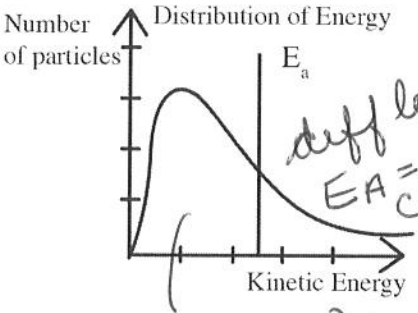
A)



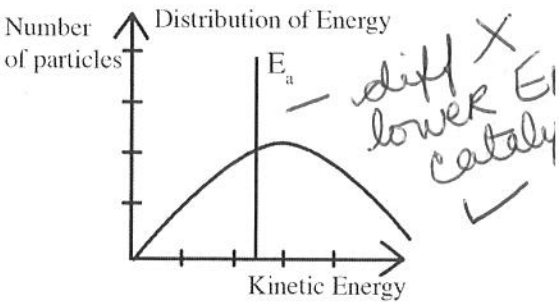
C)



B)



D)



8. When hydrogen gas and iodine gas react a brown gas is produced.

H_2 gas and I_2 gas are introduced into a reaction vessel and allowed to reach equilibrium according to the chemical equation below.

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2\,HI_{(g)}$$

Which are properties of this system if it is in a state of dynamic equilibrium?

1. The system is closed. ✓
2. The forward reaction must be exothermic. ✗
3. The colour of the gas in the reaction vessel becomes darker with time. ✗
4. The forward and reverse reactions are occurring at the same rate. ✓
5. The concentration of the reactants and products are constant. ✓

A) 1, 2, and 4

B) 1, 3, and 5

C) 1, 4, and 5

D) 2, 3, and 4

9. One of the steps in the manufacture of sulphuric acid is converting sulphur dioxide, SO_2, into sulphur trioxide, SO_3.

This reaction was allowed to reach equilibrium in a reaction vessel according to the following equation:

3n gas 2n gas

$$2\,SO_{2(g)} + O_{2(g)} \rightleftharpoons 2\,SO_{3(g)} \qquad \Delta H = -196\ kJ/mol$$

The pressure of the system was then decreased.

What will happen when the pressure of the system decreases?

A) The reactants will be favoured. ✓

B) The products will be favoured. ✗

C) The ΔH will increase. ✗ no change when shift!

D) The concentration O_2 will decrease. ✗

stress = ↓P
want = ↑P = more gas particle
shift = ← to ↑ # n gas

ΔH stays the same no matter what

10. Consider the following system at equilibrium:

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

no solids or liquids bec you cannot change their concentration

At equilibrium, the concentration of $NO_{2(g)}$ is 3.0 M, of $H_{2(g)}$ is 1.0 M and of $NH_{3(g)}$ is 2.0 M.

What is the value of the equilibrium constant, K_c ?

$$K = \frac{[NH_3]^2}{[NO_2]^2[H_2]^7} = \frac{(2)^2}{(3)^2(1)^7} = \frac{4}{9} =$$

A) 9.00

B) 2.25

C) 0.67

D) 0.44

Part B

Constructed-Response Questions 11 to 25

Answer questions 11 to 25 in your ***Student Booklet***, showing all work.

Part B

Constructed-Response Questions 11 to 25

Show all the work needed to solve the problem

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.

Significant figures will be evaluated in question 16 only.

11. April, Rachelle and Gary decided to drive up Mount Washington. A helium-filled balloon was firmly tied to the antenna of their car. At the bottom of the mountain the balloon had a volume of 2.3 L. The temperature was 24.0 °C and the pressure was 106.3 kPa.

    When they reached the summit of the mountain, they noticed the temperature was 15.2 °C and the pressure was 81.4 kPa.

    What was the volume of the balloon at the summit of the mountain?
    Assume no gas escapes from the balloon.

Show all your work:

$$\frac{T_2 P_1 V_1}{P_2 T_1} = \frac{P_2 V_2 \times T_2}{T_2 P_2}$$ (n of gas didn't Δ)

$T_1 = 24.0\,°C + 273 = 297.0\,K$

$T_2 = 15.2\,°C + 273 = 288.2\,K$

$$\frac{(288.2\,K)(106.3\,kPa)(2.3\,L)}{(81.4\,kPa)(297\,K)} = V_2 = 2.9\,L$$

The volume of the balloon at the summit of the mountain was 2.9 L.

4	3	2	1	0

12. Sodium chlorate, $NaClO_3$, is used as a source of oxygen in emergency oxygen generators found on airplanes, submarines, and the space station. When heated, the sodium chlorate contained in these oxygen generating canisters decomposes according to the following chemical equation:

solid ← (1) stoich (2) $PV=nRT$

$$2\ NaClO_{3(s)} \rightarrow 2\ NaCl_{(s)} + 3\ O_{2(g)}$$

A 250 gram sample of sodium chlorate is heated until it completely decomposes. The oxygen gas produced was collected at 101.3 kPa and 22.5 °C.

+273 = 295.5 K

What volume of oxygen gas was produced?

Show all your work.

23 + 35.5 + 16 × 3 = 48

(1) $250\text{g}\ NaClO_3 \times \frac{1\text{mol}}{106.5\text{g}} \times \frac{3\text{mol}\ O_2}{2\text{mol}\ NaClO_3} = 3.5\ \text{mol}\ O_2$

(2) $\frac{PV}{P} = \frac{nRT}{P}$

$$V = \frac{(3.5\ \text{mol})\left(8.314\ \frac{\text{kPaL}}{\text{molK}}\right)(295.5\text{K})}{(101.3\ \text{kPa})}$$

$= 85\ \text{L}$

The volume of oxygen gas produced was 85 L.

4	3	2	1	0

13. An excimer gas laser is used during corrective eye surgery to reshape the cornea. The operation of the laser involves forcing an electrical charge through a tube filled with a gas mixture.

The gas mixture used for the laser consists of hydrogen chloride gas, HCl, hydrogen gas, H_2, and neon gas, Ne.

A canister with a capacity of 14.25 L is used to store the gas mixture.

The gas is kept at a pressure of 1390 kPa and a temperature of 21.1 °C. The partial pressure of the hydrogen gas in the canister is 13.9 kPa and the partial pressure of the neon gas is 1307 kPa.

What is the mass of the HCl gas in the canister?

Show all your work.

+273 = 294.1 K

$P_{H_2} = 13.9$ kPa $P_{Ne} = 1307$ kPa

$P_T = 1390$ kPa (2) $PV = nRT$ $n = \frac{PV}{RT}$

(1) $P_T = P_1 + P_2 + P_3$

$P_T - P_1 - P_2 = P_3$

$1390\ kPa - 13.9\ kPa - 1307\ kPa = P_{HCl}$

$P_{HCl} = 69.1$ kPa

$= \frac{(69.1)(14.25)}{(8.314)(294.1)} = 0.403$ mol HCl

(3) $P_{HCl} = \frac{n_{HCl}}{n_T} \times P_T \Rightarrow \frac{P_{HCl} \times n_T}{P_T} = n_{HCl}$

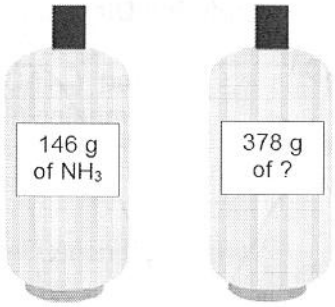
(3) $0.403\ mol\ HCl \times \frac{36.5\ g\ HCl}{1\ mol} = 14.5\ g\ HCl$

The mass of HCl gas in the canister is 14.5g. HCl

4	3	2	1	0

14. A company produces NH_3, CO_2, F_2 and He gases for industrial uses.

A gas cylinder is filled with 146 grams of NH_3. A second identical gas cylinder is filled with 378 grams of one of the other gases produced at the company, at the same temperature and to the same pressure. However, the cylinder was not labelled correctly.



Which of the gases produced at the company is in the second cylinder?

Show all your work.

same T, P, V ∴ same # n gas
same # particles ga

$146\,g\,NH_3 \times \frac{1\,mol\,NH_3}{17\,g\,NH_3} = 8.59\,mol\,NH_3 = 8.59\,mol\,X$

$\frac{378\,g\,X}{8.59\,mol\,X} = mm\,X = \frac{44.0\,g}{1\,mol} = CO_2$ $\quad 12 + 16\times2 = 32$

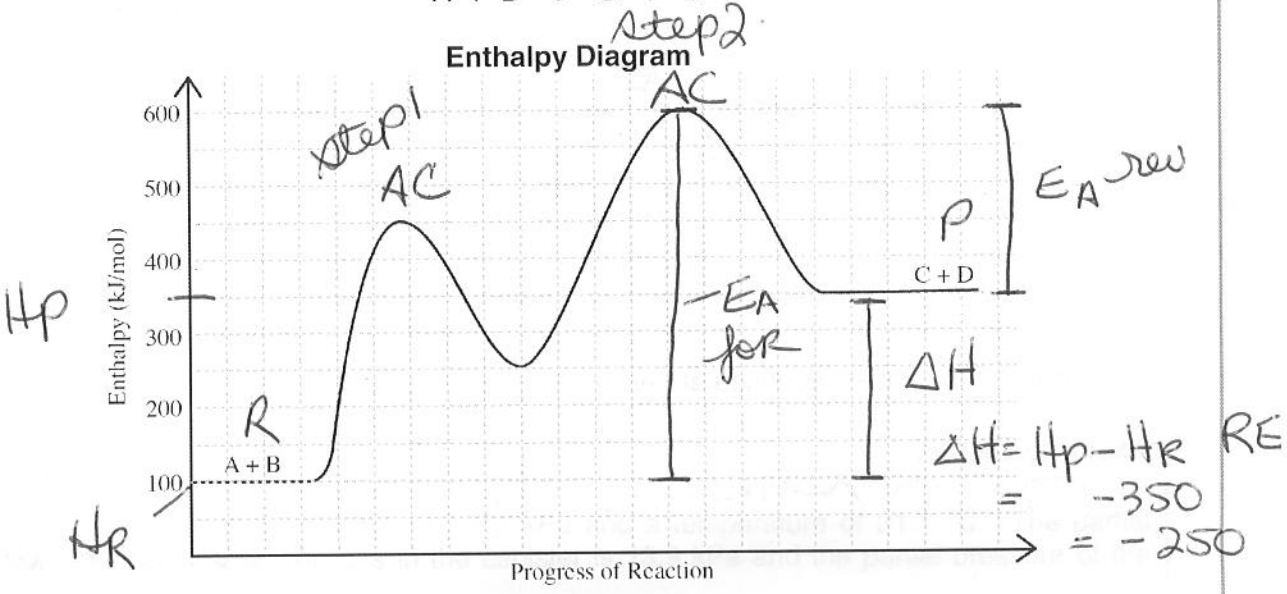
$\frac{44\,g}{1\,mol}$

The unknown gas in the second cylinder is CO_2.

4	3	2	1	0

15. The enthalpy diagram below represents the variation in potential energy for a reaction that occurs in 2 steps:

$A + B \rightarrow C + D$



a) How many activated complexes are formed?

The number of activated complexes formed is 2.

1 0

b) What is the enthalpy change, ΔH, of the reverse reaction?

The ΔH of the reverse reaction is −250 kJ/mol

1 0

c) What is the value of the activation energy, E_a, for step 1 of the forward reaction?

The value of E_a for step 1 of the forward reaction is 350 kJ/mol.

$H_R \rightarrow$ top of "bump" 450 − 100

1 0

d) If a catalyst were added, would you be able to calculate the enthalpy change of the forward reaction? Explain your answer.

answer

- yes bec a catalyst lowers the E_A
- it does not change the enthalpy of the R or P ∴ does not alter ΔH!
- the rxn just speeds up but same R & P!

1 0

16. Octane, C_8H_{18}, is the primary ingredient in gasoline. A chemist is studying the energy content of this fuel and allows octane to combust in a calorimeter.

$12\times8=96$ $1\times18=18$ 114 g/mol

The following data were collected:

Combustion of Octane, C_8H_{18}, in a calorimeter

Mass of octane (C_8H_{18}) burned	1.00 g
Volume of Water in calorimeter	1400 mL
Initial temperature of water	21.25 °C
Final temperature of water	28.82 °C

What is the molar heat of combustion for octane?
Assume no heat loss.

-2 if use 1.00g -1 if wrong conversion

Show all your work. Significant figures will be evaluated for this question.

(1) $Q_{water} = (1400\,g)\left(4.19\,\frac{J}{g\cdot°C}\right)(28.82°C-21.25°C)$

$= 44400\ J$

(2) $Q_{sub} = -44400\ J$

(3) $n_{sub} = 1.00\,g\ oct \times \frac{1\ mol\ Oct}{114\,g} = 0.00877\ mol$

(4) $\Delta H = \frac{Q_{sub}}{n_{sub}} = \frac{-44400\,J}{0.00877\ mol}$

$= -5.06\times10^{6}\,\frac{J}{mol}$ -1 if -ve sign no on ΔH but here in calc.

$= -5.06\times10^{3}\,\frac{kJ}{mol}$ -2 if ΔH not -ve

The molar heat of combustion for octane is _____.

4	3	2	1	0

17. A new process is being developed at a biotechnology company. The process uses an enzyme that only functions well at a temperature of 25 °C ± 3 °C.

For one step of the process, technicians are hoping to neutralize NaOH with HCl.

However, the technicians know, in order for the enzyme to function well, that they have to take into account the temperature changes of the solution as the neutralization of NaOH occurs.

Information concerning this neutralization reaction is provided below.

Volume of Base (NaOH)	250.0 mL
Concentration of Base (NaOH)	0.50 mol/L
Molar Heat of Neutralization of NaOH (ΔH)	–75.4 kJ/mol
Volume of Acid (HCl)	250.0 mL
Concentration of Acid	0.50 mol/L
Initial Temperature of Solution	25.0 °C

Will the final temperature of the solution after the neutralization has occurred be within the temperature range of 25 °C ± 3 °C so that the enzyme can function well?

Assume no heat is lost and that NaOH and HCl have the same heat capacity and density of water.

Show all your work.

$Q_{water} = mC\Delta T$ need Q!

mC mC

$\Delta H_{base} = \frac{-75.4\ kJ}{1\ mol\ B}$ ① Have $CV = n_B$

$0.50\frac{mol}{L} \times (0.2500\ L)$

$n_B = 0.125$

$= 0.13\ mol\ B$

② $\frac{-75.4\ kJ}{1\ mol\ B} \times 0.13\ mol\ B \times \frac{1000\ J}{1\ kJ} = -9802\ J = Q$

Show all your work.

(3) $Q_{water} = -Q_B$

$= +9800\,J$

(4) $\frac{Q_{water}}{mc} = \frac{mc\,\Delta T}{mc}$

$\frac{+9800\,J}{(500.\,g)\left(4.19\,\frac{J}{g\cdot°C}\right)} = \Delta T = 4.7\,°C$

(5) $\Delta T = T_f - T_i$

$T_f = \Delta T + T_i$

$= 4.7\,°C + 25.0\,°C$

$T_f = 29.7\,°C$

22°C – 28°C

range

Check one.

☐ Yes, the final temperature of the solution will be within the range for the enzyme to function well.

☒ No, the final temperature of the solution will not be within the range for the enzyme to function well.

4	3	2	1	0

18. When ammonia, NH_3, is exposed to air, it can oxidize according to the following chemical equation.

$$4\ NH_{3(g)} + 5\ O_{2(g)} \rightarrow 4\ NO_{(g)} + 6\ H_2O_{(g)}$$

Consider the thermochemical equations below:

	Reactions	ΔH
Reaction 1:	$N_{2(g)} + 3\ H_{2(g)} \rightarrow 2\ NH_{3(g)}$	–91.8 kJ
Reaction 2:	$2\ H_{2(g)} + O_{2(g)} \rightarrow 2\ H_2O_{(g)}$	–483.7 kJ
Reaction 3:	$N_{2(g)} + O_{2(g)} \rightarrow 2\ NO_{(g)}$	180.6 kJ
Reaction 4:	$2\ H_{2(g)} + O_{2(g)} \rightarrow H_2O_{(l)}$	–571.6 kJ

don't need this equation

What is the heat of reaction for the oxidation of ammonia?

Show all your work.

$2 \times 2NH_3 \rightarrow 2N_2 + 3 \times 3H_2$ $\quad 2(+91.8) = 183.6$

$3 \times 2H_2 + 3O_2 \rightarrow 3 \times 2H_2O$ $\quad 3(-483.7) = -1451.$

$2N_2 + 2O_2 \rightarrow 2 \times 2NO$ $\quad 2(+180.6) = +361.2$

$-906.3\ kJ$

The heat of reaction for the oxidation of ammonia is $-906.3\ kJ$.

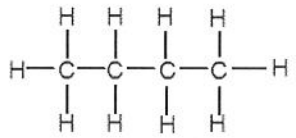
4	3	2	1	0

19. Butane torches are used by Master Chefs and home cooks alike for the finishing touches on desserts such as toasting meringues.

The chemical equation for the combustion of butane, C_4H_{10}, is given below:

$$C_4H_{10(g)} + \frac{13}{2} O_{2(g)} \rightarrow 4\ CO_{2(g)} + 5\ H_2O_{(g)} \quad \Delta H = -2172\ kJ$$

Structure of Butane



Average Bond Enthalpies in kJ/mol

C – C	347	O = O	495	O – H	?
C – H	413	C = O	745		

What is the enthalpy of the O – H bond?

Show all your work.

BER

10 C–H = 10(413) = 4130

+

$\frac{13}{2}$ O=O = $\frac{13}{2}$(495) = 3217.5

+

3 C–C = 8388.5

$BER = CO_2 + H_2O$

$\Delta H =$

$10H_2O =$ BER – CO_2

BEP

4×2 C=O = 8(745) = 596

5×2 H–O = 10(x)

BER – BEP = ΔH

∴ BEP = ΔH – BER

= −2172 –

=

The enthalpy of the O–H bond is 460 kJ. / 10

4	3	2	1	0

20. The reaction between hydrochloric acid, HCl, and calcium carbonate, $CaCO_3$ is being used to study reaction rates.

$$2\,HCl_{(aq)} + CaCO_{3(s)} \rightarrow CaCl_{2\,(aq)} + CO_{2\,(g)} + H_2O_{(l)}$$

Your teacher demonstrated the reaction by combining 1.5 grams of $CaCO_3$ chips with 75 mL of 1 M hydrochloric acid. More than 80 mL of CO_2 gas was collected.

Your chemistry teacher then challenged the class to see who could produce 10 mL of CO_2 gas using this reaction the fastest.

The following materials are available:

$CaCO_3$	HCl
1.5 grams of powdered $CaCO_3$	100 mL of 1 M HCl
2.0 grams of $CaCO_3$ chips	75 mL of 2 M HCl

Choose the combination of $CaCO_3$ and HCl that would produce 10 mL of CO_2 gas the fastest. Justify your choice.

Assume all reactions are conducted at the same pressure and temperature.

Choice	Justification
$CaCO_3$ *(Check one)* ☑ 1.5 grams of powdered $CaCO_3$ ☐ 2.0 grams of $CaCO_3$ chips	↑ SA = ↑ rate = ↑ # coll =
HCl *(Check one)* ☐ 100 mL of 1M HCl ☑ 75 mL of 2 M HCl	↑ [ ] = ↑ # coll = ↑ rate

4	3	2	1	0

21. The most cost-efficient method currently used in the industrial manufacture of hydrogen gas is steam hydrocarbon reforming. During this process, methane, CH_4, is treated with steam, H_2O, and hydrogen gas, H_2, is produced.

This reaction takes place according to the following equation:

206 + $CH_{4(g)} + H_2O_{(g)} \rightleftharpoons CO_{(g)} + 3\ H_{2(g)}$ $\Delta H = 206$ kJ/mol endo !

As the demand for H_2 gas may increase for use in fuel cells, manufacturers are seeking ways to increase its production.

Will the following modifications favour the production of H_2 gas? Explain your answer using Le Chatelier's Principle.

Modification	Is Production of H_2 favoured? (Yes or No)	Explanation
a) Increasing Temperature stress want = ↓T shift =	yes.	stress = ↑T want = ↓T shift = →
b) Adding a Catalyst	no	a cat ↑ the rate of the for x rev rxns => you get to the exact same ⇌ position only faster

***Note**: No marks are awarded without an explanation.*

4	3	2	1	0

22. If an individual's blood becomes too acidic, it can cause health problems.

A buildup of lactic acid results in 'acidosis' while a buildup of uric acid can result in another condition called 'hyperuricemia'. In both cases these acids change the pH of the blood by the production of hydronium ions, H_3O^+.

To better understand these diseases, a research biochemist is investigating the strength of these acids.

Lactic Acid
The K_a of lactic acid was determined to be 1.4×10^{-4} at 25 °C.

$$C_2H_4OHCOOH_{(aq)} + H_2O_{(l)} \rightleftharpoons C_2H_4COO^-_{(aq)} + H_3O^+_{(aq)}$$

Uric Acid
A uric acid solution with an initial concentration of 2.0×10^{-1} M was allowed to reach equilibrium at 25 °C. The pH of the solution at equilibrium was 3.1.

$$C_5H_4N_4O_{3(aq)} + H_2O_{(l)} \rightleftharpoons C_5H_3N_4O_3^-{}_{(aq)} + H_3O^+_{(aq)}$$

Which of the 2 acids is strongest, lactic acid or uric acid?

Show all your work.

Uric: $pH = -\log[H^+]$

$3.1 = -\log[H^+]$ shift log (-3.1)

$[H^+] = 7.94 \times 10^{-4}$ mol/L

$K_A = \frac{[H^+][A^-]}{[HA]} = \frac{(7.94 \times 10^{-4})^2}{(2.0 \times 10^{-1})} = 3.1 \times 10^{-6}$

NO RICE necessary → $\%\ \text{ion} = \frac{7.94 \times 10^{-4}}{2.0 \times 10^{-1}} \times 100 = 0.397\%$.

K_A lactic > K_A uric

Check one

The strongest acid is ☒ **lactic acid** ☐ **uric acid.**

4	3	2	1	0

23. The magnesium cation, Mg^{2+}, is the second most abundant cation in seawater. Two common sea salts contain magnesium; magnesium chloride, $MgCl_2$, and magnesium sulphate, $MgSO_4$.

The solubility equilibrium for each of these sea salts is shown below.

Sea Salt	Solubility Equilibrium	Ksp at 25 °C
Magnesium chloride	$MgCl_2(s) \rightleftharpoons Mg^{2+}_{(aq)} + 2\ Cl^-_{(aq)}$	7.38×10^2
Magnesium sulphate	$MgSO_4(s) \rightleftharpoons Mg^{2+}_{(aq)} + SO_4^{2-}_{(aq)}$	4.67

Which salt will produce the higher solubility of the magnesium cation at 25 °C?

Show all your work.

the bier the Ksp the bier the [ions]

(i) $Ksp = [Mg^{2+}][Cl^-]^2 = 7.38 \times 10^2$

$(x)\ (2x)^2 =$

$4x^3 =$

$x = 5.69\ \frac{mol}{L}\ Mg^{2+}$

(ii) $Ksp = [Mg^{2+}][SO_4^{2-}] = 4.67$

$(x)\ (x) =$

$x^2 = 4.67$

$x = 2.16\ \frac{mol}{L}\ Mg^{2+}$

The salt that will produce the higher solubility of the magnesium cation at 25 °C is

$MgCl_2$.

4	3	2	1	0

24. The body's digestive enzymes, needed to catalyze critical reactions, require specific pH levels in order to function properly. The table below gives some examples of digestive enzymes and their optimum pH levels.

except $K_w \neq 1 \times 10^{-14}$ bec $T = 37°C$ not 25°C

pH Levels for Optimum Enzyme Activity

Enzyme	Optimum pH
Lipase	8.1
Pepsin	1.5 - 1.6
Maltase	6.1 - 6.8

a) The concentration of the hydroxide ion, $[OH^-]$, in one part of the digestive system is 5.0×10^{-8} M.

Which of the digestive enzymes listed above would function optimally at this concentration?

$$K_w = [H^+][OH^-] = 1 \times 10^{-14}$$

$$[H^+] = \frac{1 \times 10^{-14}}{5.0 \times 10^{-8}} = 2 \times 10^{-7} M$$

$$pH = -\log[H^+]$$

$$= -\log(2 \times 10^{-7}) = 6.70\ pH$$

The enzyme that would function optimally is: maltase.

2	1	0

b) Lipase acts on food passing through the small intestine, where the pH of the digestive juices is 8.0.

What is the hydrogen ion $[H^+]$ concentration of the small intestine?

$$pH = -\log[H^+]$$

$$[H^+] = 1 \times 10^{-8} \frac{mol}{L}$$

The hydrogen ion concentration is 1×10^{-8} m.

2	1	0

25. Aniline, $C_6H_5NH_2$, is a weak base that is used in the manufacture of various products, including polyurethane foam and Kevlar.

When a 0.80 M aniline solution dissolves in water the following equilibrium is established:

$$C_6H_5NH_{2\,(aq)} + H_2O_{(l)} \rightleftharpoons C_6H_5NH_3{}^+{}_{(aq)} + OH^-{}_{(aq)}$$

At 25.0 °C, the pH of this equilibrium mixture is 9.24.

Determine the base dissociation constant, K_b, of aniline at 25.0 °C.

Show all your work.

$$K_B = \frac{[C_6H_5NH_3^+][OH^-]}{[C_6H_5NH_2]}$$

$$pH = 9.24 \rightarrow [H^+] = 5.75 \times 10^{-10}$$

$$\therefore [OH^-] = \frac{1 \times 10^{-14}}{5.75 \times 10^{-10}} = 1.80 \times 10^{-5} \frac{mol}{L}$$

$$K_B = \frac{(1.80 \times 10^{-5})^2}{(0.80)} = 4.05 \times 10^{-10}$$

The K_b for aniline is 4.05×10^{-10}.

4	3	2	1	0