ALEXANDER ROAD HIGH SCHOOL

JUNE 2021	**PHYSICAL SCIENCES ASSESSMENT**	3 HOURS
CO, JA, MH	**GRADE 12**	TOTAL = 150

Instructions:

- The question paper consists of 9 questions.
- Answer all the questions.
- Answer sections A and C on the answer sheet provided.
- Answer sections B and D on folio sheets.
- A non-programmable calculator may be used.
- Number the answers correctly according to the numbering system.
- Round off to at least two (2) decimal places where necessary.
- A formula sheet has been provided at the end of the question paper.
- A periodic table has been provided on the back of the answer sheet.

PHYSICS

SECTION A

(answer on the answer sheet)

QUESTION 1:

Four possible options are provided as answers to the following questions. Each question has only one correct answer. Choose the correct answer and write the letter (A – D) next to the relevant question number (1.1 – 1.4) on the answer sheet.

1.1 When a car suddenly brakes, a package on the front seat slides forwards and falls onto the floor. This happened because…

A. …there was a net force acting on the package pushing it forwards.

B. …an object at rest will remain at rest unless a non-zero net force acts on it.

C. …the inertia of the package resists a change in its motion.

D. …for every action there is an equal reaction.

1.2 If Earth has a gravitational acceleration **g,** then a planet with twice the mass but half the radius of Earth will have a gravitational acceleration of…

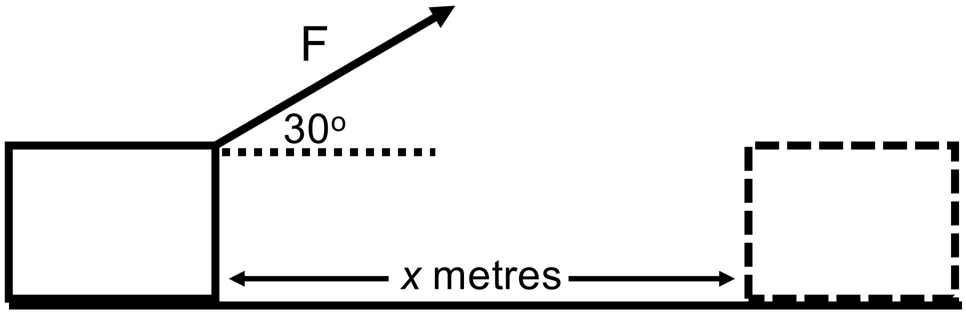
A. 4**g**

B. 8**g**

C. 16**g**

D. 9,8 $m.s^{-2}$

1.3 A force **F** pulls a box $\boldsymbol{x}$ metres to the right. The force acts 30° to the horizontal as shown in the diagram below.



The work done by **F** on the box is…

A. $\mathbf{F}\boldsymbol{x}$

B. $\mathbf{F}\boldsymbol{x}\cos 30°$

C. $\mathbf{F}\boldsymbol{x}\sin 30°$

D. 0, i.e. **F** does no work on the box.

1.4 An astronomer observes that the light spectrum of a star has been red shifted. How has the observed frequency of light from the star and the distance between the star and the Earth changed?

	Observed Frequency of Light	**Distance Between the Star and Earth**
A.	Increased	Increased
B.	Increased	Decreased
C.	Decreased	Increased
D.	Decreased	Decreased

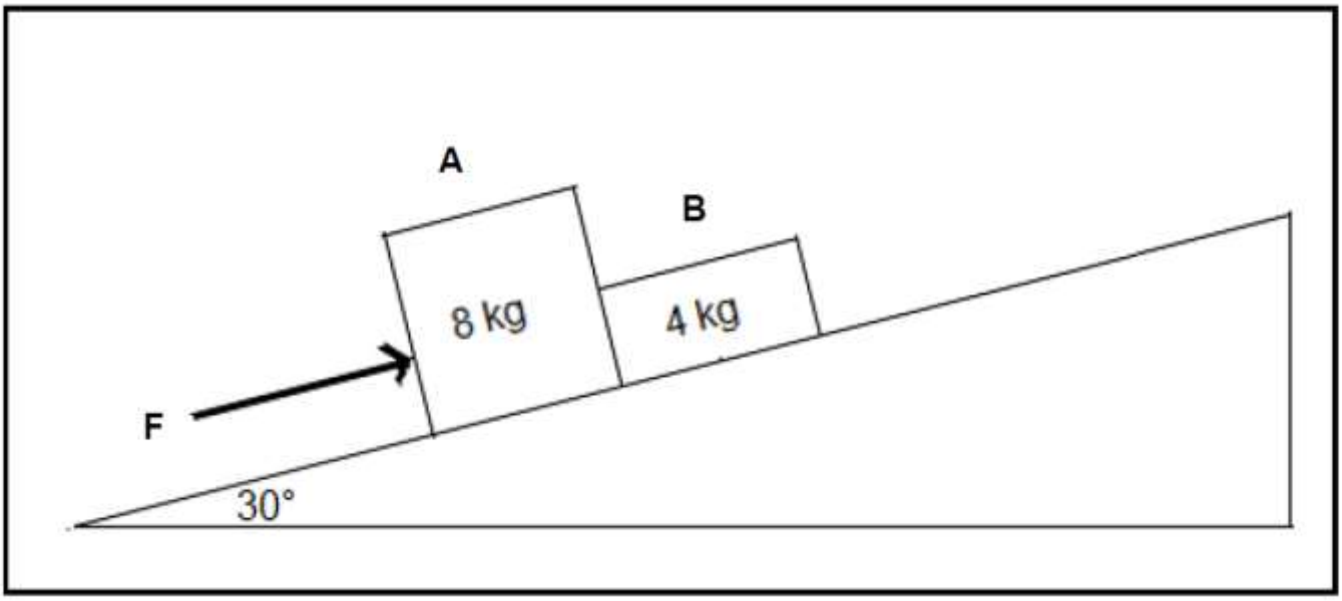
TOTAL SECTION A = [8]

SECTION B

(answer on folio paper)

QUESTION 2:

Two objects, **A** and **B**, of mass 8 kg and 4 kg respectively, are in contact. They lie on a plane inclined at 30° to the horizontal. A force, **F**, applied parallel to the incline, pushes on the objects as shown in the diagram below. The magnitude of kinetic frictional force acting on object **A** is 6,8 N and on object **B** is 3,4 N.



2.1 State *Newton's Second Law of motion* in words. (2)

2.2 Draw a labelled free-body diagram of the forces acting on **B** as it moves up the inclined plane. (4)

2.3 Calculate the:

2.3.1 Magnitude of **F** if the system moves up the inclined plane at CONSTANT VELOCITY. (5)

2.3.2 Coefficient of kinetic friction for **B**. (3)

2.4 The angle between the incline and the horizontal changes to 35°.

2.4.1 How will the answer in QUESTION 2.3.2 be affected? Write down INCREASES, DECREASES or REMAIN THE SAME. (1)

2.4.2 How will the magnitude of the kinetic frictional force on object **B** be affected? Write INCREASES, DECREASES or REMAIN THE SAME. **Explain your answer.** (3)

[18]

QUESTION 3:

A train approaches a station at a constant speed of 20 $m \cdot s^{-1}$ with its whistle blowing at a frequency of 458 Hz. An observer, standing on the platform, hears a change in pitch as the train approaches him, passes him and moves away from him.

3.1 State the phenomenon that explains the change in pitch heard by the observer. (2)

3.2 Calculate the frequency of the sound that the observer hears while the train is approaching him. Use the speed of sound in air as 340 $m \cdot s^{-1}$. (4)

3.3 How will the observed frequency change as the train passes and moves away from the observer?
Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)

3.4 How will the wavelength observed by the train driver compare to that of the sound waves emitted by the whistle? Write down only GREATER THAN, EQUAL TO or LESS THAN. **Give a reason for the answer.** (3)

3.5 If a whistle with a lower frequency is used by the train and the train's velocity increases by 5 $m \cdot s^{-1}$ as it passes the observer, how will the observed frequency change?
Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)

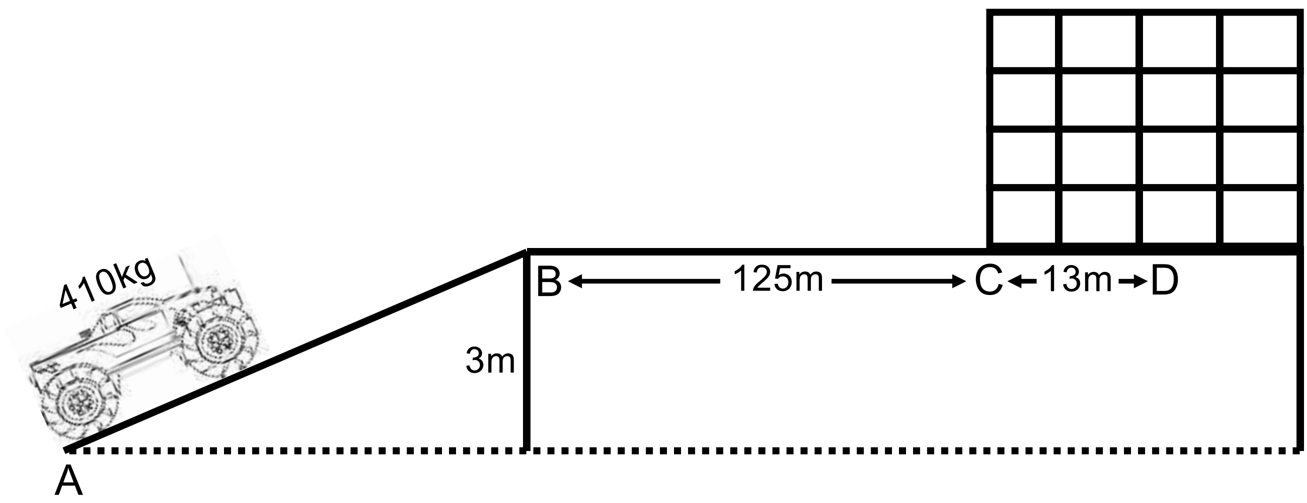
3.6 Name one use of this phenomenon in the field of medicine. (1)

3.7 How do we know the universe is expanding? (3)

[15]

QUESTION 4:

As part of a stunt, a 410 kg monster truck drives up a smooth, inclined ramp **AB** at a constant speed of 20 $m.s^{-1}$ taking 2 s to reach **B** which is 3 m above the ground as shown in the diagram below. (The diagram is not drawn to scale).



Upon reaching **B**, the truck accelerates along a rough, horizontal plane **BCD** reaching a velocity of 35 $m.s^{-1}$ to the right at **C**. From **B** to **C** the average forward force exerted by the monster truck's engine is 3 527 N and the distance is 125 m.

The monster truck collides with a brick wall at **C**, which instantaneously destroys the engine, and comes to rest in 13 m at **D**. Ignore the effects of air resistance and any deformation that may occur as the monster truck collides with the wall.

4.1 Define the term *conservative force*. (2)

4.2 State the *work-energy theorem* in words. (2)

4.3 State the two energy conversions that take place as the monster truck moves from **B** to **C**. (2)

4.4 Calculate:

4.4.1 The average power produced by the monster truck's engine to move the monster truck up the inclined ramp **AB**. (5)

4.4.2 The maximum heat (in J) produced by the monster truck's wheels from **B** to **C**. (4)

4.4.3 The average force exerted by the wall on the monster truck as the monster truck moves from **C** to **D**. **Use energy principles** to determine the answer. (6)

4.5 Is the force calculated in question 4.4.3 a NON-CONSERVATIVE or a CONSERVATIVE force? (1)

[22]

TOTAL SECTION B = [55]

CHEMISTRY

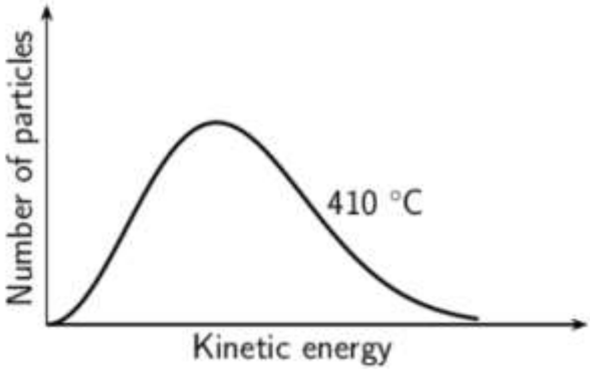
SECTION C

(answer on the answer sheet)

QUESTION 5:

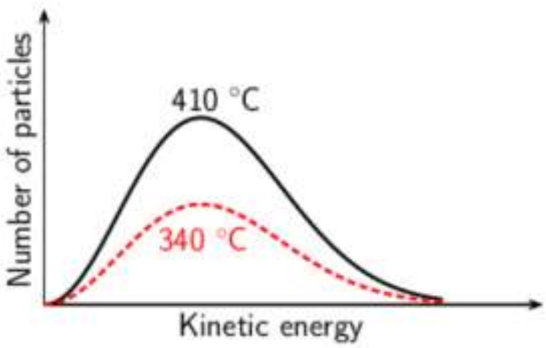
Four possible options are provided as answers to the following questions. Each question has only one correct answer. Choose the correct answer and write the letter (A – D) next to the relevant question number (5.1-5.6) on the **answer sheet**.

5.1 The following Maxwell-Boltzmann distribution curve is drawn for a sample of a substance at 410°C.

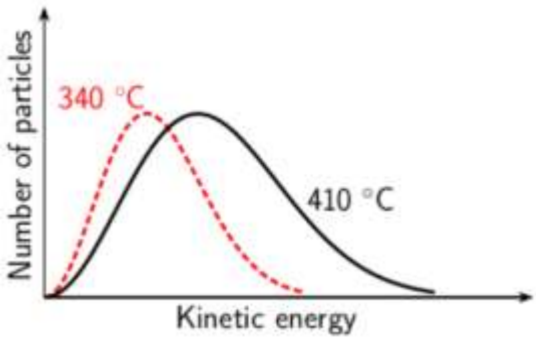


Which ONE of the following curves correctly depicts the same sample at 340°C?

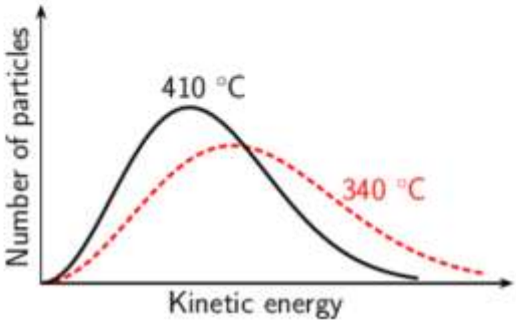
A.



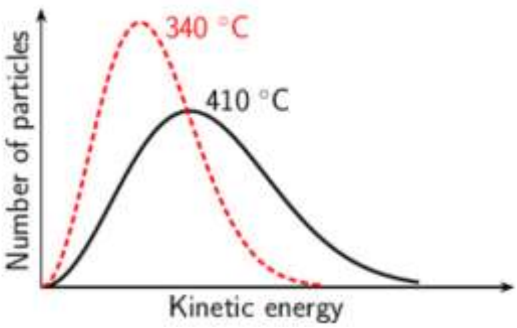
B.



C.



D.



5.2 Chemical equilibrium is defined as…

A. …a dynamic equilibrium in which the rate of the forward reaction is equal to the rate of the reverse reaction.

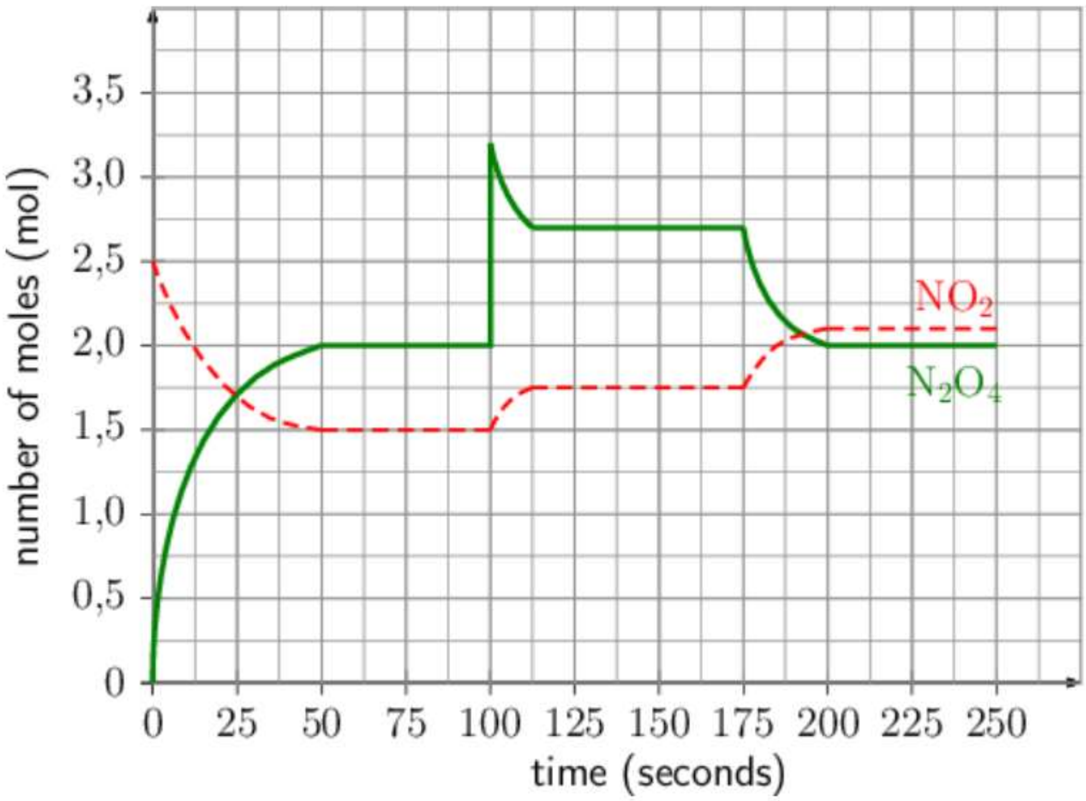
B. …a dynamic equilibrium in which both the forward and reverse reaction have both simultaneously stopped.

C. …a dynamic equilibrium in which the concentration of the products must be equal to the concentration of the reactants.

D. …a dynamic equilibrium in which products can be converted back to reactants and vice versa.

5.3 Consider the following chemical equilibrium and the associated mole-time graph:

$$2NO_{2(g)} \rightleftharpoons N_2O_{4(g)} \qquad \Delta H < 0$$



At exactly 100 s:

A. The temperature was increased.

B. The pressure was decreased

C. The amount of N_2O_4 was increased.

D. The amount of NO_2 was increased.

5.4 250 cm^3 nitrogen is added to an excess of hydrogen gas to form ammonia. The reaction takes place at a temperature of 500 K and a pressure of 600 kPa. What is the volume of the ammonia produced? Assume all the nitrogen reacts.

A. 250 cm^3

B. 500 cm^3

C. 166,67 cm^3

D. 5 dm^3

5.5 A sulphuric acid solution, $H_2SO_{4(aq)}$, and an oxalic acid solution, $(COOH)_{2(aq)}$, of EQUAL CONCENTRATIONS are compared. How do the H_3O^+ concentration and pH of $H_2SO_{4(aq)}$ solution compare to that of $(COOH)_{2(aq)}$ solution?

	$[H_3O^+]$ of $H_2SO_{4(aq)}$ solution	**pH of $H_2SO_{4(aq)}$ solution**
A	Higher than	Higher than
B	Higher than	Lower than
C	Equal to	Equal to
D	Higher than	Equal to

5.6 Consider the reactant X in the following reaction:

$$X + H_2O \rightleftharpoons H_3O^+ + H_2PO_4^-$$

The formula for X is:

A. PO_4^{3-}

B. $H_2PO_4^-$

C. HPO_4^{2-}

D. H_3PO_4

TOTAL SECTION C = [12]

SECTION D

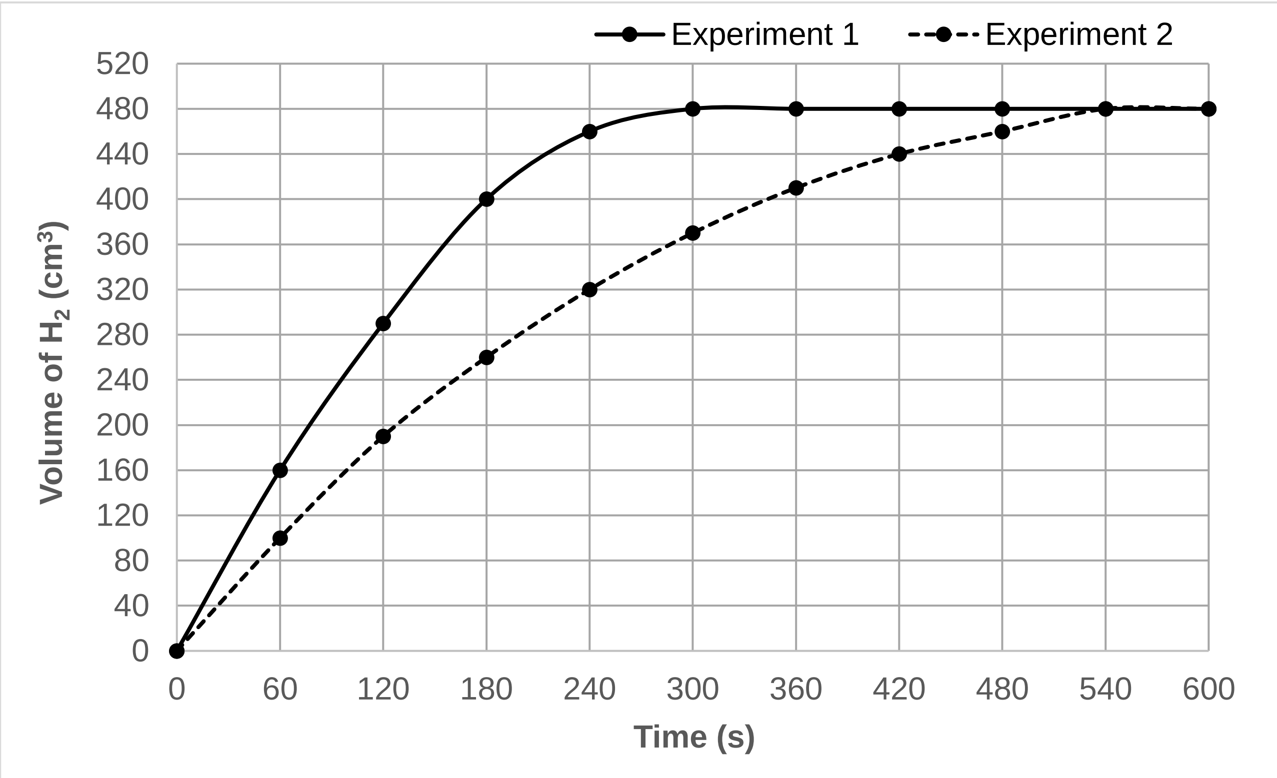
(answer on folio paper)

QUESTION 6:

Scientists react 2 g of Zn with excess HCℓ to produce H_2 gas according to the following balanced chemical equation.

$$Zn_{(s)} + 2\ HC\ell_{(aq)} \rightarrow ZnC\ell_{2(aq)} + H_{2(g)}$$

The scientists then repeat the experiment keeping all variables EXCEPT the temperature the same as before. The volume of H_2 gas produced every 60 s is measured for both experiments and plotted to obtain the following graph:



6.1 Define *reaction rate*. (2)

6.2 Write an investigative question for the experiments. (2)

6.3 Name one control variable. (1)

6.4 Which experiment was conducted at a higher temperature?
Use the graph to **give a reason** for your answer. (2)

6.5 Calculate the average reaction rate for experiment 2. (3)

6.6 If the 2 g of Zn contained no impurities, how would the average reaction rate for experiment 2 change? Write only INCREASES, DECREASES or REMAINS THE SAME. **Give a reason for your answer**. (2)

6.7 Experiment 2 was conducted at room temperature. If the molar volume of H_2 at room temperature is 24 $dm^3.mol^{-1}$, calculate the percentage purity of the Zn used in the reaction. (5)

6.8 Sketch the potential energy diagram for the reaction if it is exothermic. **Indicate** the activation energy and heat of reaction **on the sketch**. (3)

[20]

QUESTION 7:

7.1 State *Le Chatelier's principle*. (2)

7.2 Inside any bottle of fizzy drink (like Coke), the following dynamic equilibrium is occurring

$$CO_{2(g)} + H_2O_{(\ell)} \rightleftharpoons H_2CO_{3(aq)}$$

7.2.1 If the lid of the bottle is opened slightly some of the CO_2 will escape. Explain how this change will affect the equilibrium using Le Chatelier's principle. (2)

7.2.2 Which reaction will be favoured if the volume of the bottle is decreased? (1)

7.2.3 Write an expression for calculating the equilibrium constant for this reaction. (2)

7.3 The Haber-Bosch process is used to produce over 175 million tonnes of ammonia (NH_3) each year in an industry estimated to be worth over $100 billion. The balanced equation for the Haber-Bosch process is

$$N_{2(g)} + 3\,H_{2(g)} \rightleftharpoons 2\,NH_{3(g)} \qquad \Delta H < 0$$

7.3.1 Is the forward reaction ENDOTHERMIC or EXOTHERMIC? (1)

7.3.2 The equilibrium constant at a particular temperature is 50,7. The temperature is then changed resulting in a new equilibrium constant of 4,63. Did the temperature INCREASE or DECREASE? **Explain your answer.** (4)

7.3.3 0,07 mol N_2 reacts with 0,15 mol H_2 in a 0,5 dm^3 container at 0°C. At equilibrium it is found that 896 cm^3 NH_3 is present at STP. Calculate K_c at 0°C. (8)

[20]

QUESTION 8:

If a solution of silver nitrate ($AgNO_3$) is mixed with a solution of potassium chloride ($KC\ell$), a precipitate of silver chloride ($AgC\ell$) is produced according to the following reaction:

$$AgNO_{3(aq)} + KC\ell_{(aq)} \rightarrow AgC\ell_{(s)} + KNO_{3(aq)}$$

50 cm^3 of a $KC\ell$ solution with a concentration of 0,25 mol.dm^{-3} is added to 65 cm^3 of a $AgNO_3$ solution with a concentration of 0,2 mol.dm^{-3}.

8.1 Define the term *limiting reagent*. (2)

8.2 Calculate the mass of the $AgC\ell$ which is theoretically expected to form. (7)

The precipitate is filtered, dried and measured and it is found that 0,9 g of $AgC\ell$ formed.

8.3 Calculate the percentage yield of the reaction. (2)

[11]

QUESTION 9:

Consider the balanced equations for water with nitric acid and ammonia below:

Reaction 1: $HNO_{3(aq)} + H_2O_{(\ell)} \rightarrow NO^-_{3(aq)} + H_3O^+_{(aq)}$

Reaction 2: $NH_{3(aq)} + H_2O_{(\ell)} \rightarrow NH^+_{4(aq)} + OH^-_{(aq)}$

9.1 Define a *base* in terms of the Lowry-Brønsted theory. (1)

9.2 Write down the FORMULA of ONE conjugated acid-base pair in Reaction 2. (1)

9.3 Define the term *ampholyte*. (2)

9.4 Write down the FORMULA of a substance that acts as an ampholyte in the reactions above. (1)

9.5 Explain your answer in 9.4 by referring to the role of the substance in Reaction 1 and Reaction 2. (2)

X is a monoprotic acid. A sample of acid X is titrated with a standard sodium hydroxide ($NaOH$) solution using a suitable indicator. At the endpoint it is found that 25 cm^3 of acid X is neutralised by 27 cm^3 of the $NaOH$ solution of concentration 0,15 $mol.dm^{-3}$. Calculate:

9.6.1 The pH of the $NaOH$ solution. (3)

9.6.2 The concentration of acid X. (5)

9.7 The concentration of H_3O^+ ions in the sample of acid Y is found to be 1,5 x 10^{-3} $mol.dm^{-3}$. Is Y a STRONG or a WEAK acid?

Give a reason for your answer. (2)

9.8 Based on your answer in 9.7, suggest a suitable indicator for the titration. (1)

9.9 Define *hydrolysis* in terms of salts. (2)

9.10 Write down the balanced equation for the hydrolysis of NH_4Cl. (3)

9.11 Will a solution of NH_4Cl be ACIDIC or ALKALINE? (1)

[24]

TOTAL SECTION D = [75]

GRAND TOTAL = [150]


IT'S FINALLY OVER
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Formula Sheet

PHYSICS

Physical Constants:

Name	Symbol	Value
Acceleration due to gravity	g	$9,8\ m.s^{-2}$
Gravitational constant	G	$6,67 \times 10^{-11}\ N.m^2.kg^{-2}$
Radius of Earth	R_E	$6,38 \times 10^6\ m$
Mass of Earth	M_E	$5,98 \times 10^{24}\ kg$
Speed of light in a vacuum	c	$3,0 \times 10^8\ m.s^{-1}$
Planck's constant	h	$6,63 \times 10^{-34}\ J.s$
Coulomb's constant	k	$9,0 \times 10^9\ N.m^2.C^{-2}$
Charge on electron	e	$-1,6 \times 10^{-19}\ C$
Electron mass	m_e	$9,11 \times 10^{-31}\ kg$

Formulae:

MOTION

$v_f = v_i + a\Delta t$	$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$
$v_f^2 = v_i^2 + 2a\Delta x$	$\Delta x = \left(\frac{v_i + v_f}{2}\right)\Delta t$

FORCE

$F_{net} = ma$	$w = mg$
$f_s^{max} = \mu_s N$	$f_k = \mu_k N$
$F = G\frac{m_1 m_2}{r^2}$	$g = G\frac{M}{r^2}$

WORK, ENERGY AND POWER

$W = F\Delta x \cos\theta$	$E_p = mgh$
$E_k = \frac{1}{2}mv^2$	$W_{net} = \Delta E_k$ $\Delta E_k = E_{k,f} - E_{k,i}$
$W_{nc} = \Delta E_k + \Delta E_p$	$P = \frac{W}{\Delta t}$
$P_{ave} = F.v_{ave}$	

WAVES, SOUND AND LIGHT

$v = f\lambda$	$T = \frac{1}{f}$
$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$	$E = hf$ or $E = \frac{hc}{\lambda}$

Formula Sheet

CHEMISTRY

Physical Constants:

Name	Symbol	Value
Avogadro's constant	N_A	$6{,}02 \times 10^{23}$ mol^{-1}
Standard pressure	p^θ	$1{,}013 \times 10^5$ Pa
Molar gas volume at STP	V_m	22,4 $dm^3.mol^{-1}$
Standard temperature	T^θ	273 K

Formulae:

CHEMISTRY

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at 298 K	