TEMASEK JUNIOR COLLEGE
2021 JC2 PRELIMINARY EXAMINATION
Higher 2

CHEMISTRY 9729/01

15 September 2021
1 hour

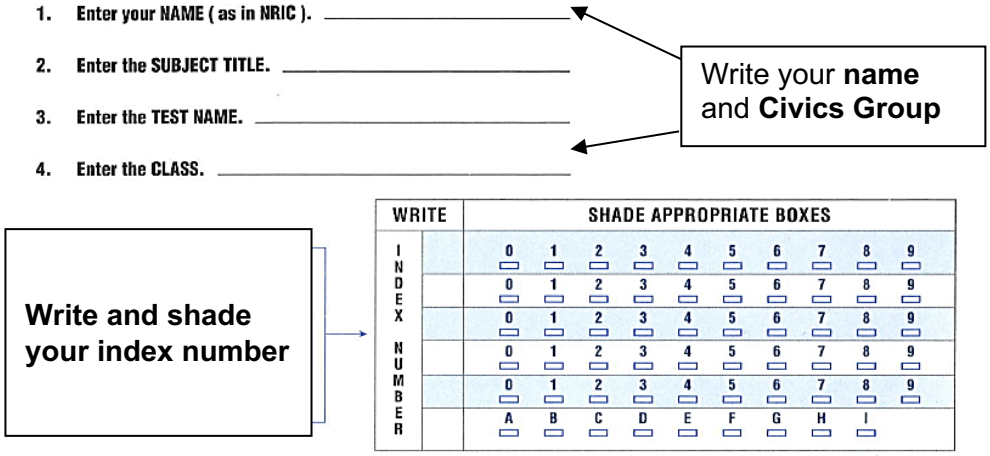
Additional Materials: Multiple Choice Answer Sheet (OMS)
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

Write your name, Class and index number on the Answer Sheet in the spaces provided.



There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **15** printed pages and **1** blank page.

1 One diatomic molecule of an element **E** has an average mass of 1.18×10^{-22} g. **E** reacts with ethene to form $C_2H_4\mathbf{E}_2$. How many **E** atoms are there in 49.5 g of $C_2H_4E_2$?

A 1.75×10^{23}

B 3.01×10^{23}

C 3.50×10^{23}

D 6.02×10^{23}

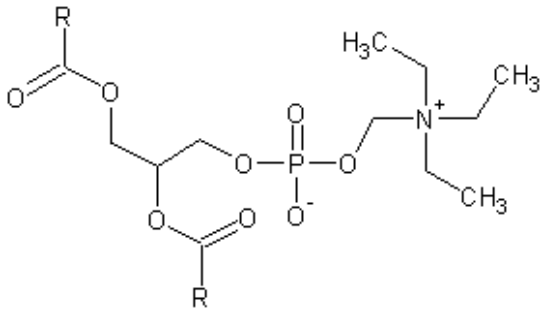
2 The radioactive isotope $^{223}_{88}Ra$ decays to give an element **Q** and emits a high energy α-particle (which is a helium nucleus, $^{4}_{2}He$). No other particle is produced.

$$^{223}_{88}Ra \longrightarrow \mathbf{Q} + {}^{4}_{2}He$$

How many neutrons are present in element **Q**?

A 219 **B** 135 **C** 133 **D** 86

3 Lecithin is an emulsifier added to chocolate to help bind the cocoa solids, sugar and milk so they stick to the cocoa butter. Its structure is shown below.



R: long hydrophobic carbon chains

Which of the following statements about lecithin is correct?

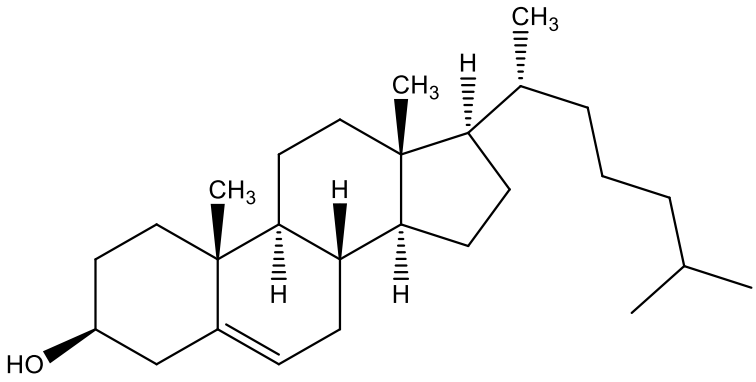
A It can form instantaneous dipole-induced dipole interactions with non-polar molecules present in chocolate.

B It can form hydrogen bonds between its own molecules.

C All bond angles surrounding each carbon atom are 109.5°.

D It does not contain delocalised electrons.

4 Cholesterol is a waxy substance that is present in blood plasma and in all animal tissues.



Cholesterol

Which of the following statements about cholesterol are **incorrect**?

1 All the seventeen carbon atoms in the four rings lie in the same plane.

2 It can exhibit cis–trans isomerism at the C=C double bond.

3 It is acidic.

A 1 only

B 1 and 2 only

C 2 and 3 only

D 1, 2 and 3

5 A sample of an organic compound of molar mass *M* is vapourised in a gas syringe and occupies *V* cm^3 at *T* K and *p* Pa.

What is the density of the compound?

A $\frac{\mathrm{p} \times \mathrm{M} \times 273}{\mathrm{T} \times 10^5 \times 22700}$

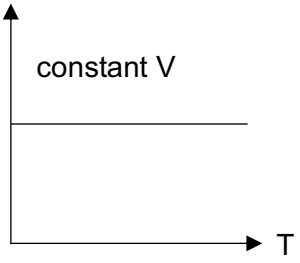
B $\frac{\mathrm{p} \times \mathrm{M} \times 293}{\mathrm{T} \times 10^5 \times 24000}$

C $\frac{\mathrm{p} \times \mathrm{M} \times 10^5 \times 22700}{\mathrm{T} \times 273}$

D $\frac{\mathrm{p} \times \mathrm{M} \times 273}{\mathrm{T} \times 22700}$

6 Which graphs correctly describe the behaviour of a fixed mass of an ideal gas (where T is measured in K)?

1



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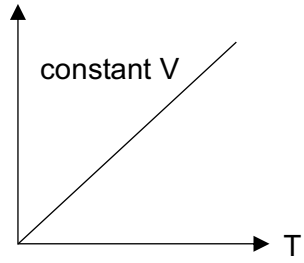

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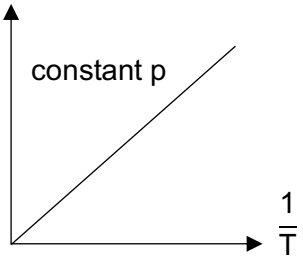


A 1 only

B 1 and 2 only

C 2 and 3 only

D 1, 2 and 3

7 **X** is a Period 3 chloride.

When a few drops of water are added to **X**, steamy white fumes are evolved and a colourless liquid is produced.

Which compound is **X**?

A $MgCl_2$

B $AlCl_3$

C $SiCl_4$

D PCl_5

8 **X** and **Y** are two elements in Period 3 of the Periodic Table. They combine to form compound **Z**. Both **X** and **Y** form oxides that react with aqueous sodium hydroxide. The oxidation number of **X** in its oxide is +4.

What is the formula of compound **Z**?

A AlP

B Al_2S_3

C Si_3P_4

D SiS_2

9 The solids, sodium chloride and sodium iodide, both react with concentrated sulfuric acid at room temperature.

With NaC*l*, the products are $NaHSO_4$ and HC*l*.

With NaI, the products are $NaHSO_4$, HI, I_2, SO_2, H_2O, S and H_2S.

Which of the following is the best explanation for this difference in products?

A Chloride will displace iodine from solution.

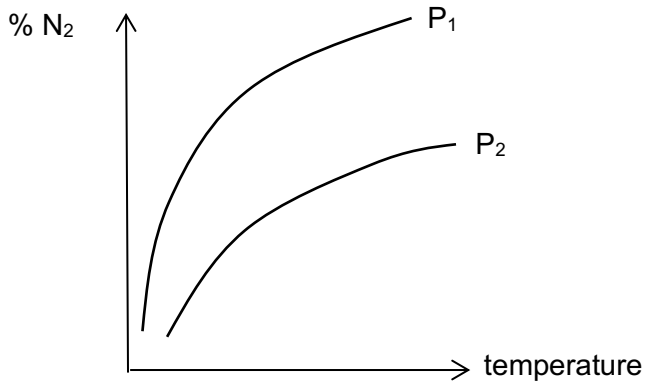
B Iodine is a better oxidising agent than chlorine.

C Iodide is a better reducing agent than chloride.

D Sulfuric acid is able to act as a dehydrating agent with NaI.

10 The graph below shows how the percentage of $N_2(g)$ in the equilibrium mixture of the Haber process varies with temperature at different pressures, P_1 and P_2.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H_r$$



Which row in the table is correct?

	ΔH_r	Pressure
A	positive	$P_1 > P_2$
B	positive	$P_1 < P_2$
C	negative	$P_1 > P_2$
D	negative	$P_1 < P_2$

11 The position of equilibrium lies to the right in each of these reactions.

Reaction 1: $N_2H_4 + HClO \rightleftharpoons N_2H_5^+ + ClO^-$

Reaction 2: $N_2H_5^+ + NH_3 \rightleftharpoons NH_4^+ + N_2H_4$

Based on this information, which statements are correct?

1 ClO^- is the conjugate base of HC*l*O.

2 $N_2H_5^+$ is the Bronsted base in Reaction 2.

3 The order of acid strength is HC*l*O > $N_2H_5^+$ > NH_4^+.

4 N_2H_4 is the Lewis acid in Reaction 1.

A 1 and 3 only **B** 1 and 4 only **C** 2 and 3 only **D** 2 and 4 only

12 Which of the following solutions does not change its pH significantly when a small amount of base is added?

A 20 cm^3 of 0.10 mol dm^{-3} ethanoic acid mixed with 20 cm^3 of 0.20 mol dm^{-3} aqueous sodium hydroxide.

B 20 cm^3 of 0.10 mol dm^{-3} aqueous ammonia mixed with 30 cm^3 of 0.10 mol dm^{-3} hydrochloric acid.

C 20 cm^3 of 0.10 mol dm^{-3} sodium hydroxide mixed with 20 cm^3 of 0.20 mol dm^{-3} phenylammonium chloride.

D 20 cm^3 0.10 mol dm^{-3} hydrochloric acid mixed with 10 cm^3 0.1 mol dm^{-3} sodium ethanoate solution.

13 A student dissolved 8.4 g of sodium fluoride in 250 g of water.

Given the following thermodynamic data,

Lattice energy of NaF	−918 kJ mol^{-1}
Enthalpy change of hydration of F^-	−457 kJ mol^{-1}
Enthalpy change of hydration of Na^+	−390 kJ mol^{-1}

What would be the initial temperature of the water if the final temperature of the solution is 20.00 ºC? Assume that the specific heat capacity of sodium fluoride solution is 4.2 J g^{-1} K^{-1}.

A 6.48 ºC **B** 20.01 ºC **C** 33.08 ºC **D** 33.52 ºC

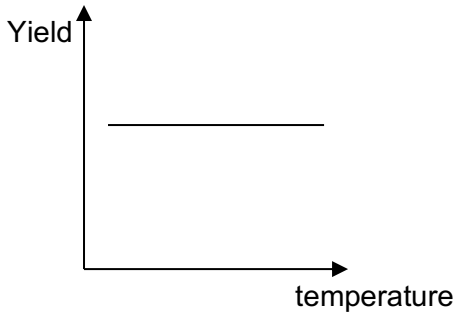
14 In oil refineries, an important process is the recovery of any sulfur from petroleum.

$$2H_2S(g) + O_2(g) \rightleftharpoons 2H_2O(g) + 2S(s)$$

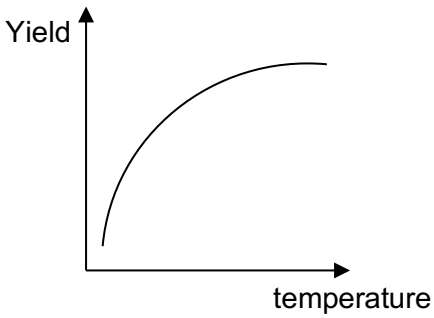
The enthalpy change of formation of $H_2S(g)$ is -20.5 kJ mol^{-1} and that of $H_2O(g)$ is -243.0 kJ mol^{-1}.

Which of the following describes how the yield of sulfur at equilibrium varies as temperature increases?

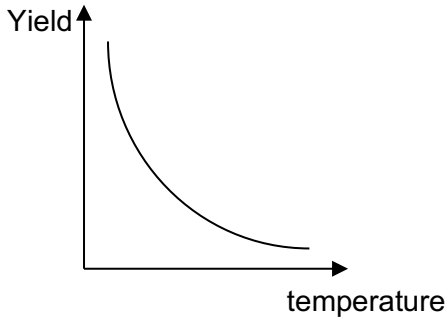
A



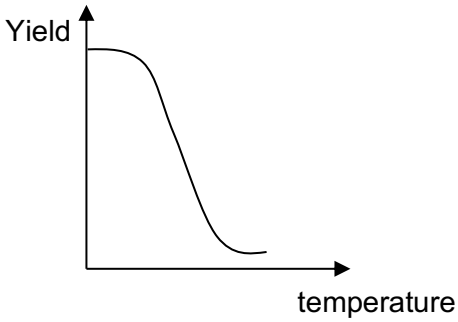
B



C



D



15 Which of the following is true about the value of rate constant of a pseudo first order reaction?

A It depends on the concentration of reactants present in limited amount.

B It depends on the concentration of reactants present in excess amount.

C It is independent of the concentration of reactants.

D It depends only on temperature and presence of catalyst.

16 Consider the following reaction involving aqueous reactants **S** and **T**, and catalysed by **U**:

$$\mathbf{S} + \mathbf{T} \rightarrow \mathbf{V} + \mathbf{W}$$

The solution is originally coloured due to reactant **T**. The kinetics of the above reaction is studied by measuring the time taken for the solution to decolourise. The results are obtained below.

Experiment	Volume of **S** / cm^3	Volume of **T** / cm^3	Volume of **U** / cm^3	Volume of water added / cm^3	Time taken / s
1	10	5	5	5	20
2	5	5	5	10	40
3	10	5	2.5	7.5	40
4	10	2.5	5	7.5	10

What is the rate law for the reaction above?

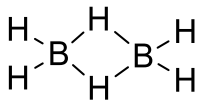
A Rate = k[**S**][**T**][**U**]

B Rate = k[**S**][**T**]

C Rate = k[**T**][**U**]

D Rate = k[**S**][**U**]

17 Diborane, B_2H_6, is a colorless gas with a sweet odour. The structure is unique as it comprises of two bridging hydrogens shared between two boron atoms. The B_2H_2 ring contains two B-H-B bonds, each held together by two electrons.



Diborane

Which of the following statements are correct about diborane?

1 The boron atom is sp^2-hybridised.

2 Only boron is electron deficient.

3 All B-H bonds in diborane have the same bond strength.

A 1 and 3 only

B 1 and 2 only

C 2 and 3 only

D 2 only

18 Colourless liquid **L** with the molecular formula, $C_5H_{11}Cl$, exists as a mixture of two enantiomers. When heated with sodium hydroxide in methanol, a mixture of only two alkenes is formed.

What is structure of **L**?

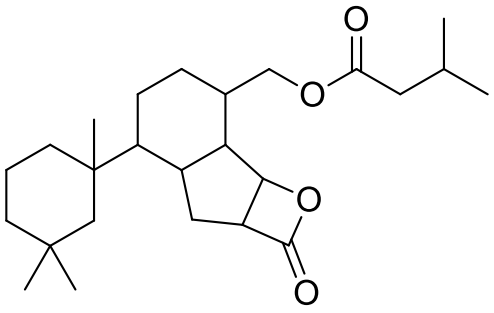
A $(CH_3CH_2)_2CHCl$

B $CH_3CH_2CH_2CHClCH_3$

C $(CH_3)_2CHCHClCH_3$

D $CH_3CH_2CCl(CH_3)_2$

19 The structure of compound **T** is shown below.



compound **T**

How many chiral centers does 1 molecule of **T** have?

A 5 **B** 6 **C** 7 **D** 8

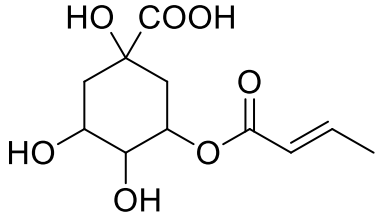
20 When heated with chlorine, 2-methylpentane undergoes substitution. In one of the steps, the free radical, Q•, is formed.

2-methylpentane + C*l*• → Q• + HC*l*

How many different forms of Q• are theoretically possible?

A 4 **B** 5 **C** 6 **D** 7

21 Compound **X** has the following structure.



Which of the following is **incorrect**?

A When it is heated with acidified potassium manganate(VII), carbon dioxide gas is produced.

B It can react with phenol to form an ester in the presence of concentrated sulfuric acid.

C It can react with up to 2 moles of sodium hydroxide under suitable conditions.

D It reacts with excess sodium metal to produce 2 moles of hydrogen gas.

22 Compound **P** has the following properties.

- It gives white fumes when it is mixed with PCl_5.
- It turns hot acidified potassium dichromate(VI) green.

Which of the following can be **P**?

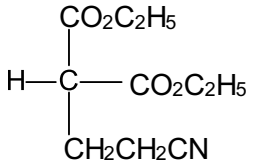
A $(CH_3)_2C(OH)CH_2CH_3$

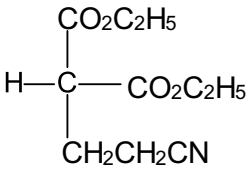
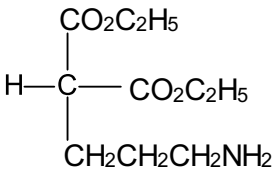
B $HO_2CCH_2COCH_3$

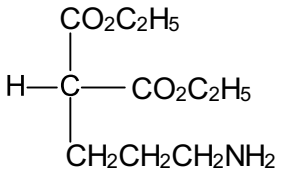
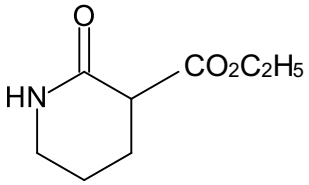
C $HCOCH_2CH_2OH$

D $CH_3C_6H_4CO_2H$

23 Proline, an amino acid, can be synthesised in the laboratory via a multi-stage synthetic route. Some of the stages are shown below:

Stage 1 $CH_2(CO_2C_2H_5)_2 + CH_2{=}CHCN \longrightarrow$ 

Stage 2  reagent **V** $\longrightarrow$ 

Stage 3  $\longrightarrow$  + **Y**

W **X**

Which of the following statements are correct?

1 Stage 1 is an addition reaction.

2 Reagent **V** is lithium aluminum hydride.

3 **W** reacts with 3 moles of bromoethane and the product formed is more basic than **W**.

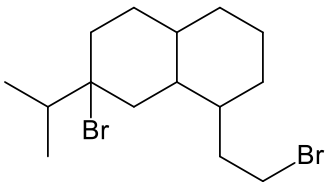
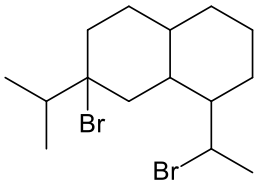
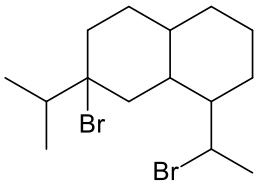
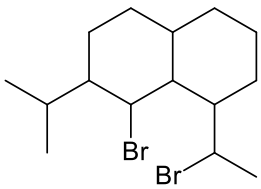
4 **Y** gives a yellow precipitate when it is warmed with aqueous alkaline iodine.

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

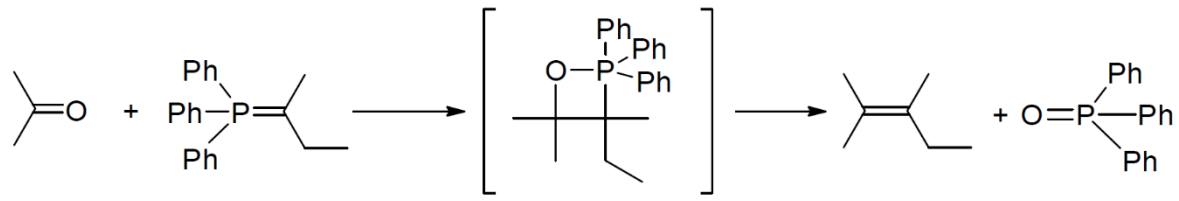
24 Compound **P** reacts with HBr to form the major product, **Q**. It further undergoes a reaction in step **2** to form **R**.

P

Which row is correct?

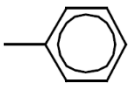
	Structure of **Q**	Reagent and condition for step **2**
A		Alcoholic KCN, heat
B		Alcoholic KCN, heat
C		Excess conc. ammonia in ethanol, heat in sealed tube
D		Excess conc. Ammonia in ethanol, heat in sealed tube

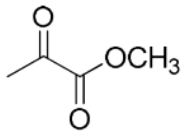
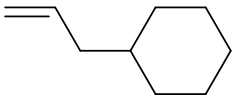
25 The Wittig reaction involves the reaction of a carbonyl compound with a phosphorus ylide to give an alkene. The reaction occurs via an oxaphosphetane intermediate.

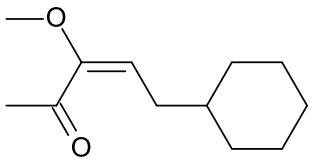


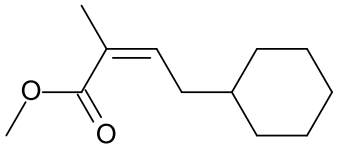
phosphorus ylide

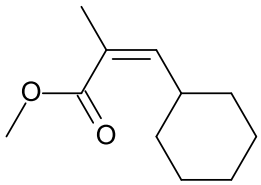
oxaphosphetane

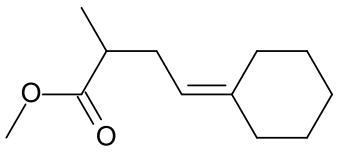
(–Ph = )

Which of the following is the product formed when  reacts with $(Ph)_3P$  ?

A 

B 

C 

D 

26 Dichloromethane is reacted with excess chlorine in the presence of sunlight.

What could be the products of this reaction?

A $CHCl_3$ and H_2

B $CHCl_3$ and CCl_3CHCl_2

C CCl_4 and CH_2ClCCl_3

D CH_2ClCH_2Cl and HCl

27 Which set of data shows calcium as a typical s-block element and copper as a typical transition element?

	property	calcium	copper
1	density / g cm^{-3}	1.54	8.92
2	electrical conductivity / relative units	85	9.6
3	melting point / °C	1083	810
4	metallic radius / nm	0.117	0.197

A 1 only

B 1 and 3 only

C 2 and 3 only

D 1, 2, 3 and 4

28 Which of the following statements about the nitration of aromatic compounds are correct?

A Phenol reacts with dilute nitric acid to a pale yellow precipitate.

B The nitration of phenylethanone is faster than ethylbenzene.

C The nitration of phenylethanone requires a lower temperature than phenylamine.

D Phenol requires both concentrated nitric acid and concentrated sulfuric acid to form 2,4,6-trinitrophenol.

29 The lead-acid rechargeable battery has electrodes of solid lead and solid lead(IV) oxide, PbO_2. When the battery discharges, solid lead(II) sulfate, $PbSO_4$ is formed. The electrolyte is an aqueous solution of sulfuric acid.

The two half-equations involved in the electrode reactions are

Electrode X: $PbSO_4(s) + H^+(aq) + 2e^- \rightleftharpoons Pb(s) + HSO_4^-(aq)$ $E^\ominus_1$

Electrode Y: $PbO_2(s) + HSO_4^-(aq) + 3H^+(aq) + 2e^- \rightleftharpoons PbSO_4(s) + 2H_2O(l)$ $E^\ominus_2$

Which statement about the discharging process is correct?

A ΔG is positive.

B $E^\ominus_1$ is more positive than $E^\ominus_2$.

C As the cell discharges, the pH decreases.

D For every 2 mole of electrons transferred, 2 mole of $PbSO_4$ is formed.

30 Two separate electrolysis experiments were performed and the volumes of gases produced were measured at the same temperature and pressure.

electrolysis 1	Molten copper(II) chloride was electrolysed for 3 minutes and 10 cm^3 of chlorine was collected.
electrolysis 2	Aqueous sodium hydroxide was electrolysed for 3 minutes and 10 cm^3 of oxygen was collected.

The current used in electrolysis 1 was x.

What was the current used in electrolysis 2?

A $\frac{x}{2}$ **B** x **C** $2x$ **D** $4x$

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