RAFFLES INSTITUTION
2021 YEAR 6 PRELIMINARY EXAMINATION

Higher 2

CHEMISTRY 9729/01

Paper 1 Multiple Choice **23 September 2021**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Do not open this question booklet until you are told to do so.

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, class and index number in the spaces provided on the Answer Sheet.

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 the question booklet.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **15** printed pages.

1 The shape of each p-orbital is represented as two lobes.

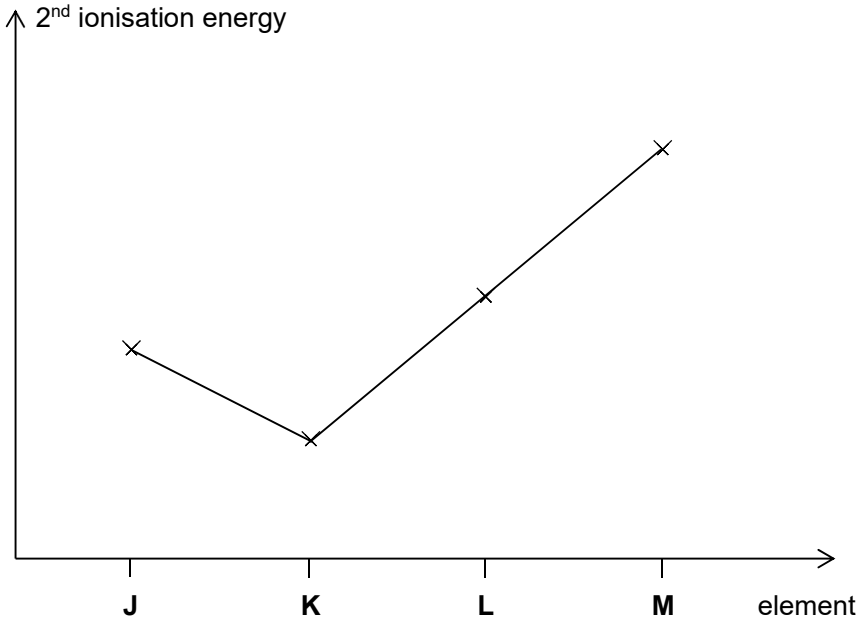
How many electrons does Cu have in orbitals with four lobes?

A 7 **B** 8 **C** 9 **D** 10

2 *Use of the Data Booklet is relevant to this question.*

Ionisation energy generally increases across a period. In Period 2, there are two irregularities which cause ionisation energy to be lower than expected.

The graph below shows the 2nd ionisation energies of four consecutive elements with atomic numbers less than 20.



What is a possible identity of **K**?

1 boron
2 carbon
3 oxygen
4 fluorine

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

3 **Q** has the following physical properties.

- It is non-volatile.
- It does not conduct electricity in its standard state.
- It dissolves in water.

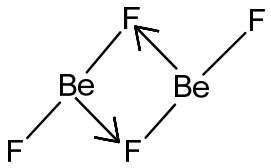
What is the identity of **Q**?

A nitrogen dioxide
B silicon dioxide
C sodium
D sodium oxide

4 Beryllium is diagonal to aluminium in the Periodic Table and they share similar properties.

Which structures for the compounds of beryllium and fluorine are possible?

1



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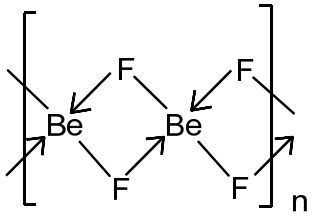

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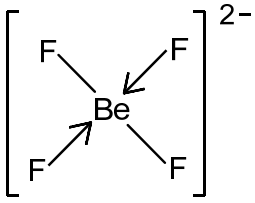


A 1, 2 and 3
B 1 and 2 only
C 2 and 3 only
D 3 only

5 **X**, **Y** and **Z** are elements in the third period of the Periodic Table. The oxide of **X** is amphoteric, the oxide of **Y** is basic and the oxide of **Z** is acidic.

What is the order of increasing ionic radius for these three elements?

A **X** < **Y** < **Z**
B **X** < **Z** < **Y**
C **Y** < **X** < **Z**
D **Y** < **Z** < **X**

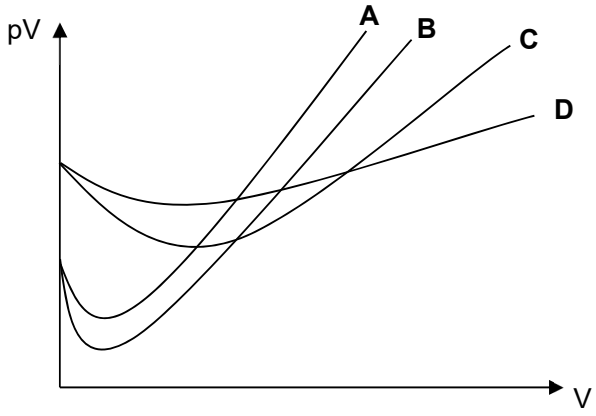
6 *Use of the Data Booklet is relevant to this question.*

Which metal ion has the highest K_a?

A $[Co(H_2O)_6]^{3+}$
B $[Mg(H_2O)_6]^{2+}$
C $[Mn(H_2O)_6]^{2+}$
D $[V(H_2O)_6]^{3+}$

7 The volumes and pressures of equal masses of four gases CH_3OH, SiH_4, HBr, and H_2Se, are separately investigated, at constant temperature. The results are plotted on a graph of pV against V.

Which plot shows the results for CH_3OH?



8 *Use of the Data Booklet is relevant to this question.*

Which halogen will not oxidise Fe^{2+} to Fe^{3+}?

A F_2 **B** Cl_2 **C** Br_2 **D** I_2

9 N_2O_5 is a compound involved in important atmospheric reactions, such as ozone depletion. It may be formed from N_2 and O_2 during electric discharge.

Given the following data, what is the ΔH_f of $N_2O_5(g)$?

$$2NO(g) + O_2(g) \longrightarrow 2NO_2(g) \qquad \Delta H = -114.1 \text{ kJ mol}^{-1}$$
$$4NO_2(g) + O_2(g) \longrightarrow 2N_2O_5(g) \qquad \Delta H = -110.2 \text{ kJ mol}^{-1}$$
$$N_2(g) + O_2(g) \longrightarrow 2NO(g) \qquad \Delta H = +180.5 \text{ kJ mol}^{-1}$$

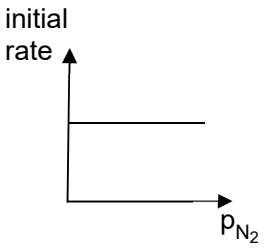
A -43.8 kJ mol^{-1}
B -21.9 kJ mol^{-1}
C $+11.3$ kJ mol^{-1}
D $+22.6$ kJ mol^{-1}

10 The Haber process involves the following reaction in the presence of an iron catalyst.

$$3H_2(g) + N_2(g) \longrightarrow 2NH_3(g)$$

Which graph shows the effect of increasing partial pressure of $N_2(g)$, p_{N_2}, on the initial rate of reaction?

A



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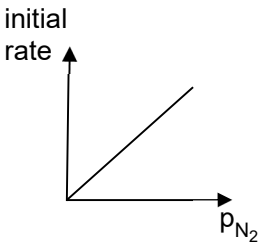

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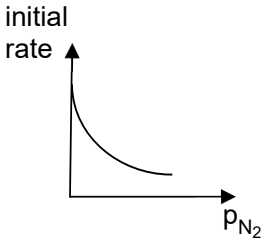

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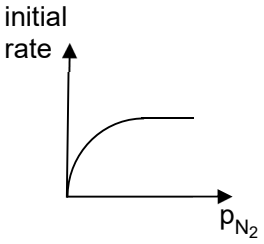
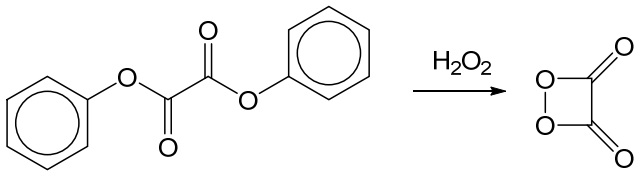


11 The reaction in a light stick involves the following reaction.



compound **P**

The reaction is first order with respect to the concentrations of both H_2O_2 and compound **P**. In a prototype light stick, where H_2O_2 is present in large excess, it was found that the concentration of compound **P** decreases to 25% of its initial concentration in 1 hour.

What is the half-life of the reaction above?

A 15 minutes
B 30 minutes
C 45 minutes
D 60 minutes

12 Ozone decomposes naturally into oxygen according to the following equation.

$$2O_3 \longrightarrow 3O_2$$

The following mechanism has been proposed.

step 1 $\quad O_3 \rightleftharpoons {}^{\bullet}O + O_2 \quad$ fast

step 2 $\quad {}^{\bullet}O + O_3 \longrightarrow 2O_2 \quad$ slow

K_1 is the equilibrium constant of step 1 and k_2 is the rate constant of step 2.

Which statements are correct for this reaction?

1 The order of reaction with respect to $[O_3]$ is 2.

2 The overall rate equation is $\text{rate} = k_2K_1\dfrac{[O_3]^2}{[O_2]}$.

3 Increasing $[O_2]$ slows down the reaction.

A 1, 2 and 3
B 1 and 3 only
C 1 only
D 2 only

13 The Contact process for producing sulfuric acid involves the following reaction.

$$2SO_2(g) + O_2(g) \underset{}{\overset{V_2O_5(s)\ \text{catalyst}}{\rightleftharpoons}} 2SO_3(g) \qquad \Delta H = -197\ \text{kJ mol}^{-1}$$

The process is carried out at 450 °C and 2 atm.

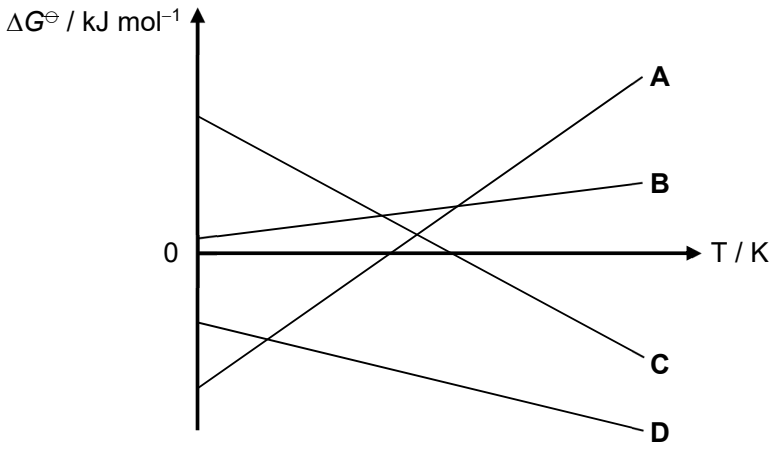
Which statements are correct?

1 At high temperature, more reactant particles have energy higher than the activation energy, thus the rate of production is faster.
2 At high temperature, more reactant particles have energy higher than the activation energy, thus a greater yield is obtained.
3 At high pressure, the rate constant of the reaction is greater, thus the rate of production is faster.
4 The presence of a catalyst increases the rate constant of the reaction, thus the rate of production is faster.

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

14 A particular reaction is endothermic. At high temperature, the ratio of $\frac{[\text{products}]}{[\text{reactants}]}$ at equilibrium is lower than 1.

Which graph represents how $\Delta G^{\ominus}$ changes with temperature for the reaction?



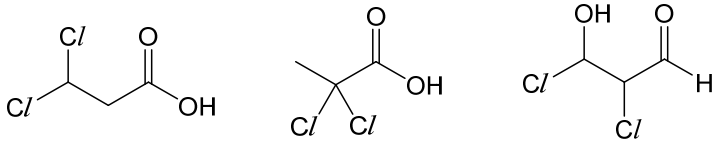
15 The value of the ionic product of water, K_w is affected by temperature.

temperature / K	$K_w \times 10^{-14}$ / mol^2 dm^{-6}
293	0.681
303	1.47

Which statement is correct?

A Water is less acidic at 293 K than at 303 K.
B The enthalpy change of ionisation of water is exothermic.
C The number of molecules in water increases from 293 K to 303 K.
D The concentration of hydroxide ions in water increases from 293 K to 303 K.

16 What is the order of decreasing pK_a for these isomers?



P **Q** **R**

A **P** > **R** > **Q**
B **Q** > **P** > **R**
C **R** > **P** > **Q**
D **R** > **Q** > **P**

17 A buffer is considered effective in resisting pH changes when the difference between its pH and pK_a is not more than 1.

A mixture was prepared by mixing 30 cm^3 of a 1 mol dm^{-3} solution of NaOH with 35 cm^3 of a 1 mol dm^{-3} solution of ethanoic acid. (K_a of ethanoic acid = 1.8×10^{-5} mol dm^{-3})

Which statements are correct?

1 The pH of the mixture is 4.74.

2 The mixture can act as an effective buffer.

3 The mixture can better resist pH changes when a small amount of alkali is added than when a small amount of acid is added.

A 1, 2 and 3
B 2 and 3 only
C 2 only
D 3 only

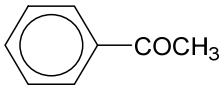
18 In a saturated aqueous solution of mercury(I) bromide, Hg_2Br_2, the following equilibrium exists.

$$Hg_2Br_2(s) \rightleftharpoons Hg_2^{2+}(aq) + 2Br^-(aq)$$

Given that the numerical value of the solubility product of mercury(I) bromide is 6.4×10^{-23}, what is the solubility of mercury(I) bromide?

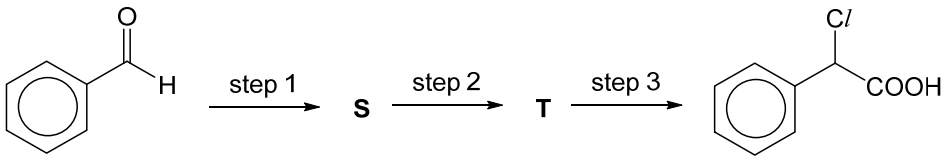
A 2.52×10^{-8} mol dm^{-3}
B 4.00×10^{-8} mol dm^{-3}
C 5.66×10^{-12} mol dm^{-3}
D 8.00×10^{-12} mol dm^{-3}

19 How many σ bonds and π electrons does the molecule below have?



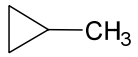
	σ bond	π electron
A	12	6
B	12	8
C	17	6
D	17	8

20 Which set of reagents and conditions can be used in the synthesis below?



	step 1	step 2	step 3
A	KCN, H_2SO_4(aq)	$SOCl_2$, anhydrous	HCl(aq), heat
B	HCN, trace KOH	HCl(aq), heat	PCl_3, anhydrous
C	ethanolic KCN, heat	$NaBH_4$	$SOCl_2$, anhydrous
D	$NaBH_4$	ethanolic KCN, heat	HCl(aq), heat

21 Compound **U** undergoes substitution with chlorine gas to form monosubstituted compounds.

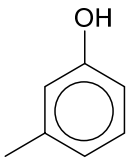


U

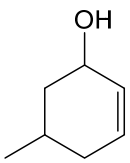
How many possible isomers, including stereoisomers, can be formed in the reaction?

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

22 Which reagents and conditions can be used to distinguish between compounds **V** and **W**?



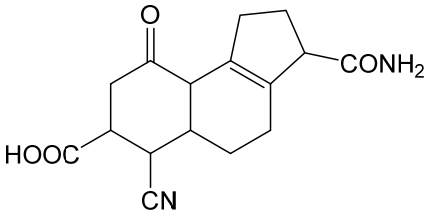
V



W

A $Na_2CO_3(aq)$
B hot acidified $KMnO_4(aq)$
C neutral $FeCl_3(aq)$
D $Br_2(aq)$

23 Which statements are correct about the compound below?



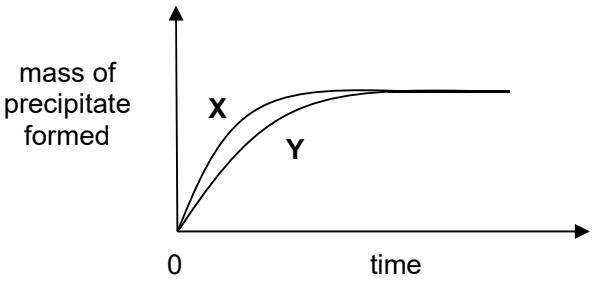
1 It reacts with H_2 in the presence of Pt catalyst to incorporate six hydrogen atoms into the compound.
2 It reacts with $LiAlH_4$ in dry ether to produce an organic compound containing one primary amine group.
3 It reacts with $NaBH_4$ to produce an organic compound containing one secondary alcohol group.

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

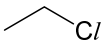
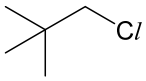
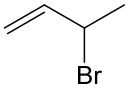
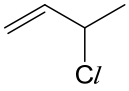
24 Two test tubes containing equal concentrations and volumes of ethanolic silver nitrate solution were placed in a heated water bath.

Equal amounts of two halogen-containing compounds, **X** and **Y**, were then added separately to these test tubes.

The mass of precipitate formed in each test tube was monitored and the results are shown graphically below.

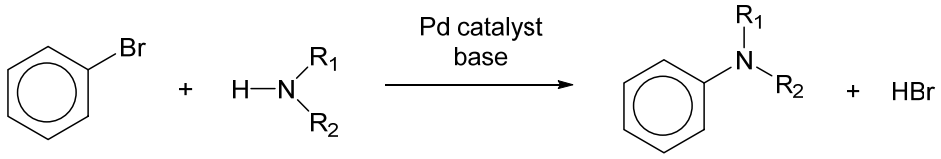


Which compounds could be **X** and **Y**?

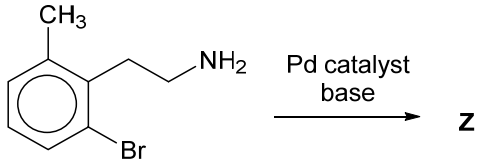
	X	**Y**
1		
2	C_2H_5COCl	$C_2H_5COCH_2Cl$
3		

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

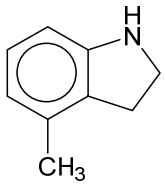
25 Buchwald–Hartwig amination is an organic reaction for the synthesis of carbon–nitrogen bonds from the reactions of amines with aryl halides.



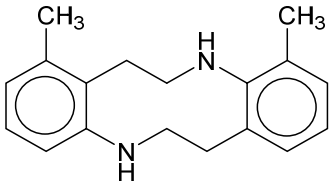
Which is **not** a possible structure for **Z**?



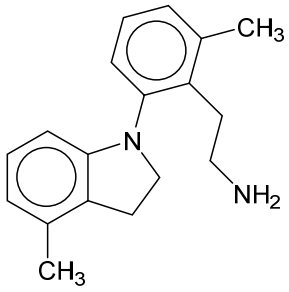
A



B



C



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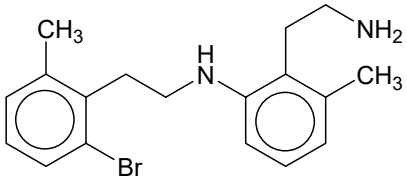


26 Compound **S** contains only carbon, hydrogen and oxygen. It gives an orange precipitate with 2,4-dinitrophenylhydrazine. When compound **S** is heated with aluminium oxide, compound **T** is the only organic compound formed. 1 mol of compound **T** reacts with only 1 mol of aqueous bromine and also reacts with hot acidified potassium manganate(VII) to give no organic product.

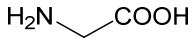
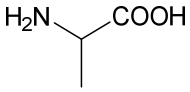
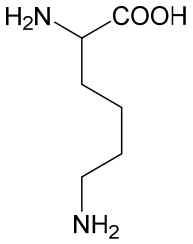
Which functional groups can be found in **S**?

1 aldehyde
2 ketone
3 primary alcohol
4 tertiary alcohol

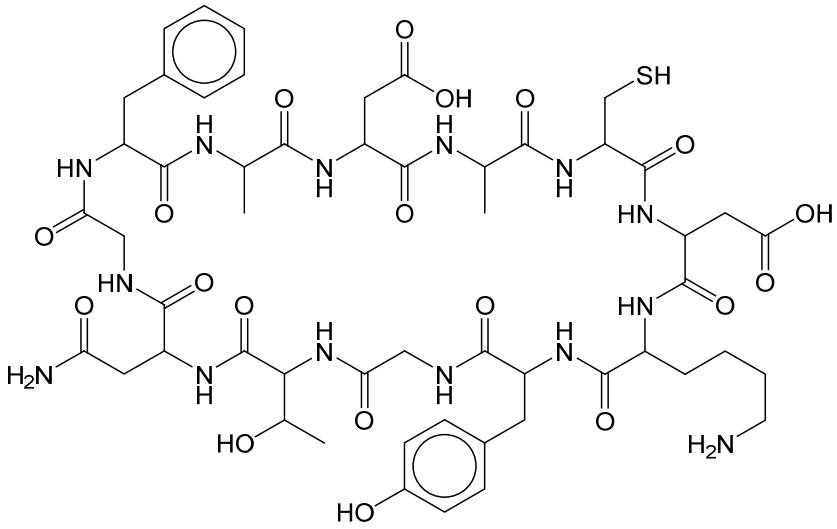
A 1 and 3
B 1 and 4
C 2 and 3
D 2 and 4

27 Enzyme **Y** will only hydrolyse a polypeptide chain at a peptide bond at the carboxylic acid end of lysine. Enzyme **Z** will only hydrolyse a polypeptide chain at a peptide bond at the carboxylic acid end of either glycine or alanine.

The structures of these amino acids are shown.

glycine	alanine	lysine
		

How many moles of dipeptides will be produced when 1 mol of the following cyclic polypeptide was hydrolysed by both enzymes **Y** and **Z**?



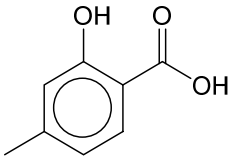
A 2 **B** 3 **C** 4 **D** 5

28 Compound **X** has the molecular formula $C_9H_{12}O_2$.

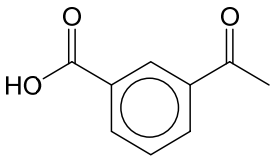
- **X** gives a yellow precipitate with alkaline aqueous iodine.
- **X** decolourises Br_2 in CCl_4.

Which compound could be the product formed when **X** is heated with acidified potassium dichromate(VI)?

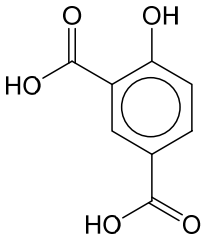
A



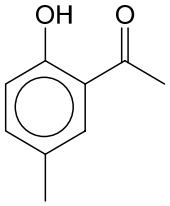
B



C



D



29 An electrochemical cell was set up under standard conditions consisting of the following half-cells.

$N_2(g) + 4H_2O(l) + 4e^- \rightleftharpoons N_2H_4(aq) + 4OH^-(aq)$ $\quad E^\ominus = -1.16$ V
$N_2H_4(aq) + 2H_2O(l) + 2e^- \rightleftharpoons 2NH_3(aq) + 2OH^-(aq)$ $\quad E^\ominus = +0.10$ V

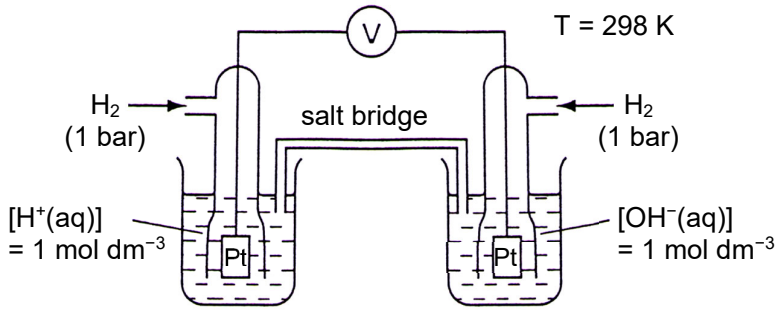
Which statements are correct?

1 The decomposition of $N_2H_4(aq)$ to $NH_3(aq)$ and $N_2(g)$ is spontaneous under basic conditions.
2 Increasing the pH in the N_2/N_2H_4 half-cell will cause $E_{cell} > E^\ominus_{cell}$.
3 Adding water to the N_2H_4/NH_3 half-cell will cause $E_{cell} > E^\ominus_{cell}$.

A 1, 2 and 3
B 1 and 3 only
C 2 and 3 only
D 1 only

30 *Use of the Data Booklet is relevant to this question.*

The following electrochemical cell was set up to investigate the $\Delta G^{\ominus}$ of neutralisation.



What is the $\Delta G^{\ominus}$ of neutralisation?

A -160 kJ mol^{-1}
B -80.1 kJ mol^{-1}
C $+80.1$ kJ mol^{-1}
D $+160$ kJ mol^{-1}