See back cover for an English translation of this cover

2

91164M

911645

SUPERVISOR'S USE ONLY

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

QUALIFY FOR THE FUTURE WORLD
KIA NOHO TAKATŪ KI TŌ ĀMUA AO!

Tohua tēnei pouaka mēnā KĀORE koe i tuhituhi i roto i tēnei pukapuka

Te Mātauranga Matū, Kaupae 2, 2021

91164M Te whakaatu māramatanga ki te honohono, te hanga, ngā āhuatanga me ngā huringa pūngao

Ngā whiwhinga: Rima

Paetae	Kaiaka	Kairangi
Te whakaatu māramatanga ki te honohono, te hanga, ngā āhuatanga me ngā huringa pūngao.	Te whakaatu māramatanga hōhonu ki te honohono, te hanga, ngā āhuatanga me ngā huringa pūngao.	Te whakaatu māramatanga matawhānui ki te honohono, te hanga, ngā āhuatanga me ngā huringa pūngao.

Tirohia mēnā e rite ana te Tau Ākonga ā-Motu (NSN) kei runga i tō puka whakauru ki te tau kei runga i tēnei whārangi.

Me whakamātau koe i ngā tūmahi KATOA kei roto i tēnei pukapuka.

He taka pūmotu kua whakaritea ki te Pukapuka Rauemi L2–CHEMMR.

Ki te hiahia koe ki ētahi atu wāhi hei tuhituhi whakautu, whakamahia te wāhi wātea kei muri i te pukapuka nei.

Tirohia mēnā e tika ana te raupapatanga o ngā whārangi 2 – 21 kei roto i tēnei pukapuka, ka mutu, kāore tētahi o aua whārangi i te takoto kau.

Kaua e tuhi ki roto i tētahi wāhi kauruku whakahāngai (). Ka tapahia pea tēnei wāhi ina mākahia te pukapuka.

ME HOATU RAWA KOE I TĒNEI PUKAPUKA KI TE KAIWHAKAHAERE Ā TE MUTUNGA O TE WHAKAMĀTAUTAU.

TŪMAHI TUATAHI

He kamupene waka ātea a Rocket Lab e whakarewa ana i ngā amiorangi kia āmio mai i Te Māhia i Aotearoa, mā tā rātou tākirirangi *Electron*.

E whakaaturia ana ētahi o ngā matū e whakamahia ana i te tākirirangi *Electron* ki te tūtohi i raro.

www rnz.co nz/news/business/437449/rocket-lab-confirms-public-listing-through-merger-deal

(a) Whakaotihia te tūtohi e whai ake mō ēnei matū ina totoka ana.

Totoka	Momo totoka	Momo korakora	Tōpana kume i waenga korakora
Hāora $O_2(s)$			
Konukura $Cu(s)$			
Matāpango $C(s)$			

(b) Whakamahia ai te konukora, $Cu(s)$, mō ngā waea tāhiko i roto i te tākirirangi, i te mea ka taea te kawe hiko me te whakatoro hei waea (kōngohe).

Mā tō mōhio ki te hanganga me te honohono, whakamāramahia ēnei āhuatanga E RUA.

He wāhi anō mō tō tuhinga mō tēnei tūmahi kei ngā whārangi o muri mai.

QUESTION ONE

Rocket Lab is an aerospace company that launches satellites into orbit from the Māhia Peninsula in New Zealand, using their *Electron* rocket.

Some substances used in the *Electron* rocket are shown in the table below.

www rnz.co nz/news/business/437449/rocket-lab-confirms-public-listing-through-merger-deal

(a) Complete the following table for these substances in their solid states.

Solid	Type of solid	Type of particle	Attractive forces between particles
Oxygen $O_2(s)$			
Copper $Cu(s)$			
Graphite $C(s)$			

(b) Copper, $Cu(s)$, is used for electrical wiring in the rocket, due to its ability to conduct electricity and be stretched into wires (ductility).

Use your knowledge of structure and bonding to explain BOTH of these properties.

There is more space for your answer to this question on the following pages.

(c) E rokirokitia ana te hāora wē, $O_2(\ell)$, ki te taika hāora o te tākirirangi. Kua hangaia tēnei taika mai i te matū hiato ā-waro, ā, kei roto ko te matāpango, $C(s)$.

I raro i te pēhanga kōhauhau, ka huri te hāora mai i te wē ki te haurehu i te –183 °C, ā, me whakawera te matāpango ki te takiwā o te 3600 °C hei huri mai i tētahi totoka ki tētahi haurehu.

Mā tō mōhio ki te hanganga me te honohono, whakamāramahia te rerekētanga nui i waenga i ngā pāmahana e huri ai ia matū hei haurehu.

(c) Liquid oxygen, $O_2(\ell)$, is stored in the oxygen tank of the rocket. This tank is made of a carbon composite material, which contains graphite, C(*s*).

Under atmospheric pressure, oxygen turns from a liquid into a gas at –183 °C, while graphite must be heated to around 3600 °C in order to turn from a solid into a gas.

Using your knowledge of structure and bonding, explain the large difference between the temperatures at which each substance turns into a gas.

TŪMAHI TUARUA

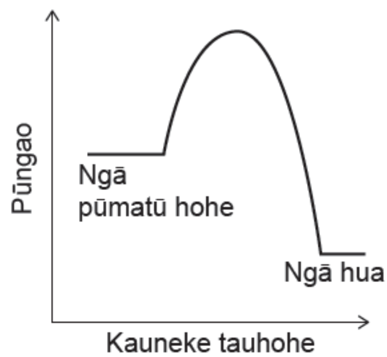
Ka whakamahi te tākirirangi *Electron* i te kora RP-1, he karahīni taumata tiketike tēnei. Ko te karahīni he ranunga waiwaro ka taea te tohu mā te ture tātai rāpoi ngota $C_{12}H_{26}$.

(a) Ka tauhohe te karahīni haurehu, $C_{12}H_{26}(g)$, ki te haurehu hāora, $O_2(g)$, i te wāhanga ngingiha o te tākirirangi, e ai ki te whārite i raro:

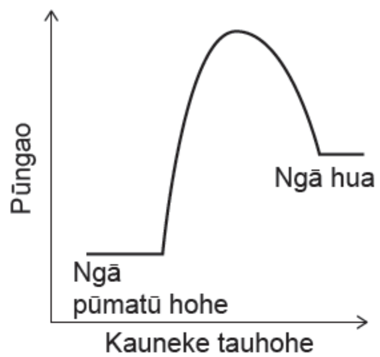
$$2C_{12}H_{26}(g) + 37O_2(g) \rightarrow 24CO_2(g) + 26H_2O(\ell) \qquad \Delta_r H^\circ = -15\,800 \text{ kJ mol}^{-1}$$

(i) Ko tēhea te hoahoa i raro e tino whakaatu ana i te kōtaha tauhohenga mō taua tauhohe matū?

Hoahoa A



Hoahoa B



Porohitatia tētahi: **Hoahoa A** **Hoahoa B**

Whakamāramahia tō whakautu.

(ii) Ki te hoahoa i kōwhiria e koe i runga ake, me mārama te tapa i te panoni o te hāwera ($\Delta_r H$).

QUESTION TWO

The *Electron* rocket uses RP-1 fuel, which is a high-grade kerosene. Kerosene is a mixture of hydrocarbons that can be represented by the molecular formula $C_{12}H_{26}$.

(a) Gaseous kerosene, $C_{12}H_{26}(g)$, reacts with oxygen gas, $O_2(g)$, in the combustion chamber of the rocket, as shown in the equation below:

$$2C_{12}H_{26}(g) + 37O_2(g) \rightarrow 24CO_2(g) + 26H_2O(\ell) \qquad \Delta_r H^\circ = -15\,800 \text{ kJ mol}^{-1}$$

(i) Which diagram below best represents the reaction profile for this chemical reaction?

Diagram A

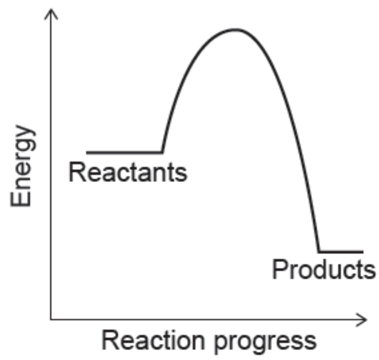
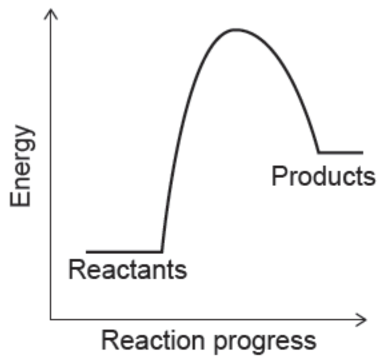


Diagram B



Circle one: **Diagram A** **Diagram B**

Explain your answer.

(ii) On the diagram that you chose above, clearly label the change in enthalpy ($\Delta_r H$).

(b) He maha ngā mīhini tākirirangi he whakamahi i te kora-mōmona, arā, kāore e whakamahia te katoa o te kora karahīni ($C_{12}H_{26}$) ka puta mā roto i te mīhini. He 2560 kg (2.56×10^6 g) te kora karahīni ka raua ki te wāhanga tuatahi o te tākirirangi; engari he 75.0% anake o tēnei ka ngingihatia (whakapetoa).

$$2C_{12}H_{26}(g) + 37O_2(g) \rightarrow 24CO_2(g) + 26H_2O(\ell) \qquad \Delta_rH° = -15\,800 \text{ kJ mol}^{-1}$$

Tātaihia te pūngao ka whakaputaina e te ngingihatanga o tēnei rahinga o te kora karahīni.

$M(C_{12}H_{26}) = 170 \text{ g mol}^{-1}$

(c) Ko te karahīni, $C_{12}H_{26}(\ell)$, he matū pitokore.

Whakamahia tō mōhio ki te hanganga me te honohono hei tautohu me te whakamārama i te mehamehanga o te karahīni i te wai me ngā tāmeha owaro hurihanga (cyclohexane).

(b) Many rocket engines run fuel-rich, which means they do not use all of the kerosene ($C_{12}H_{26}$) fuel that passes through them. 2560 kg (2.56×10^6 g) of kerosene fuel is loaded into the first stage of the rocket; however only 75.0% of this is combusted (burned).

$$2C_{12}H_{26}(g) + 37O_2(g) \rightarrow 24CO_2(g) + 26H_2O(\ell) \qquad \Delta_rH° = -15\,800 \text{ kJ mol}^{-1}$$

Calculate the energy produced by the combustion of this amount of kerosene fuel.

$M(C_{12}H_{26}) = 170 \text{ g mol}^{-1}$

(c) Kerosene, $C_{12}H_{26}(\ell)$, is a non-polar substance.

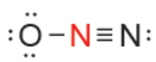
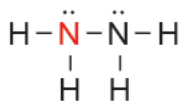
Use your knowledge of structure and bonding to identify and explain the solubility of kerosene in both water and cyclohexane solvents.

TŪMAHI TUATORU

(a) Tātuhia te hoahoa Lewis (hoahoa tongi irahiko) mō ngā rāpoi ngota e whai ake nei, ka whakaingoa i ngā āhua.

Te Rāpoi Ngota	AsF_3	H_2S	F_2CO
Hoahoa Lewis			
Ingoa āhua			

(b) E whakaaturia ana i raro ko ngā hoahoa Lewis me ngā koki hononga o ngā kora rerekē e rua i whakamahia i roto i ngā mīhini tākirirangi.

Hoahoa Lewis		
Ingoa	Hauota-rua ōkihi (N_2O)	Haitarahine (N_2H_4)
Koki hononga ki te ngota N whero	180°	109.5°

Whakamāramahia te rerekētanga i waenga i ngā āhua me ngā koki hononga ki ngā ngota hauota kua **karakaratia ki te whero** i ia rāpoi ngota.

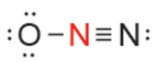
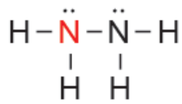
He wāhi anō mō tō tuhinga mō tēnei tūmahi kei ngā whārangi o muri mai.

QUESTION THREE

(a) Draw the Lewis diagram (electron dot diagram) for the following molecules and name their shapes.

Molecule	AsF_3	H_2S	F_2CO
Lewis diagram			
Name of shape			

(b) The Lewis diagrams and bond angles of two different propellants that have been used in rocket engines are shown below.

Lewis diagram		
Name	Nitrous oxide (N_2O)	Hydrazine (N_2H_4)
Bond angle about red N atom	180°	109.5°

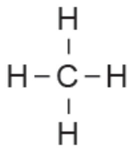
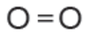
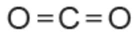
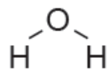
Explain the difference in the shapes and bond angles about the nitrogen atoms that are **coloured red** in each molecule.

There is more space for your answer to this question on the following pages.

(c) Ko tētahi atu kora ka taea te whakamahi i rō mīhini tākirirangi ko te mewaro, $CH_4(g)$. Ka tautohe te mewaro ki te hāora, $O_2(g)$, e ai ki te tauhohe i raro nei.

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) \qquad \Delta_r H° = –802 \text{ kJ mol}^{-1}$$

(i) Whakamahia te panoni o te hāwera ($\Delta_r H°$) mō te ngingiha o te mewaro me ngā pūngao hononga kua rārangitia i te tūtohi i raro hei tātai i te pūngao hononga toharite o te hononga C–H i te mewaro.

			
CH_4	O_2	CO_2	H_2O

Hononga	**Pūngao hononga toharite (kJ mol^{-1})**
C=O	805
O=O	495
O–H	463

(ii) Tātaihia te papatipu o te mewaro, $CH_4(g)$, ka hiahiatia kia tauhohe hei whakaputa i te 1660 kJ pūngao.

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) \qquad \Delta_r H° = –802 \text{ kJ mol}^{-1}$$

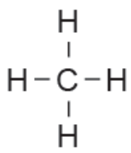
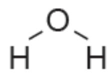
$$M(CH_4) = 16.0 \text{ g mol}^{-1}$$

Ka haere tonu te Tūmahi Tuatoru i te whārangi 18.

(c) Another fuel that can be used in rocket engines is methane, $CH_4(g)$. It reacts with oxygen, $O_2(g)$, as shown by the reaction below.

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) \quad \Delta_r H° = –802 \text{ kJ mol}^{-1}$$

(i) Use the change in enthalpy ($\Delta_r H°$) for the combustion of methane and the bond energies listed in the table below to calculate the average bond energy of the C–H bond in methane.

	O=O	O=C=O	
CH_4	O_2	CO_2	H_2O

Bond	Average bond energy (kJ mol^{-1})
C=O	805
O=O	495
O–H	463

(ii) Calculate the mass of methane, $CH_4(g)$, required to react in order to release 1660 kJ of energy.

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) \quad \Delta_r H° = –802 \text{ kJ mol}^{-1}$$

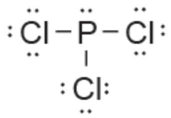
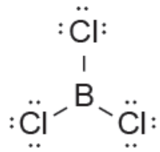
$M(CH_4) = 16.0 \text{ g mol}^{-1}$

x

(d) The Lewis diagrams of phosphorus trichloride (PCl_3) and boron trichloride (BCl_3) are shown below.

Question Three continues on page 19.

(d) E whakaaturia ana ngā hoahoa Lewis o te pūtūtaewhetū pūhaumōta-toru (PCl_3) me te pūtiwha pūhaumāota-toru (BCl_3) i raro.

	
Pūtūtaewhetū pūhaumōta-toru (PCl_3)	Pūtiwha pūhaumāota-toru (BCl_3)

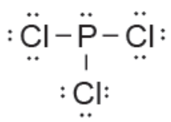
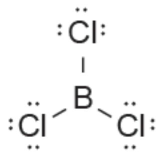
Kei roto i ngā rāpoi ngota e rua ko ngā ngota haumāota e toru e pae ana i tētahi ngota pū, engari he rerekē ngā tōranga tētahi i tētahi.

(i) Porohitatia te kupu e whakaahua ana i te tōranga o ia rāpoi ngota i raro.

Pūtūtaewhetū pūhaumōta-toru (PCl_3) **Pitorua** **Pitokore**

Pūtiwha pūhaumāota-toru (BCl_3) **Pitorua** **Pitokore**

(ii) Whakatauritea ngā pānga e whakaawe ana i te tōranga o aua rāpoi ngota e rua.

	
Phosphorus trichloride (PCl_3)	Boron trichloride (BCl_3)

Both molecules contain three chlorine atoms around a central atom, yet have different polarities.

(i) Circle the word that describes the polarity of each molecule below.

Phosphorus trichloride (PCl_3)	**Polar**	**Non-polar**
Boron trichloride (BCl_3)	**Polar**	**Non-polar**

(ii) Compare and contrast the factors that influence the polarity of these two molecules.

He whārangi anō ki te hiahiatia.
Tuhia te (ngā) tau tūmahi mēnā e tika ana.

TAU TŪMAHI

Extra space if required.
Write the question number(s) if applicable.

QUESTION NUMBER

English translation of the wording on the front cover

91164M

Level 2 Chemistry 2021

91164M Demonstrate understanding of bonding, structure, properties and energy changes

Credits: Five

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of bonding, structure, properties and energy changes.	Demonstrate in-depth understanding of bonding, structure, properties and energy changes.	Demonstrate comprehensive understanding of bonding, structure, properties and energy changes.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

A periodic table is provided in the Resource Booklet L2–CHEMMR.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–21 in the correct order and that none of these pages is blank.

Do not write in any cross-hatched area (). This area may be cut off when the booklet is marked.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.