BOND ENERGY CALCULATIONS

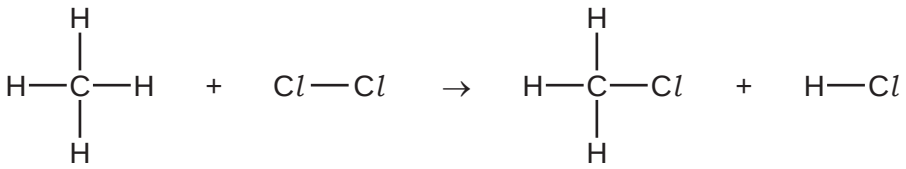
1 Bond forming is exothermic, bond breaking is endothermic. Explain the difference between an exothermic reaction and an endothermic reaction.

.....

..... [2]

exothermic reaction gives out energy [1]
endothermic reaction absorbs
takes in energy [1]

2 Use the bond energies to show that the following reaction is exothermic.
Bond energy is the amount of energy (kJ / mol) which must be supplied to break one mole of the bond.



Bond energies in kJ / mol

C*l*–C*l*	+242
C–C*l*	+338
C–H	+412
H–C*l*	+431

bonds broken	energy in kJ / mol
.....	.....
.....	.....
total energy =	.....

bonds formed	energy in kJ / mol
.....	.....
.....	.....
total energy =	.....

.....

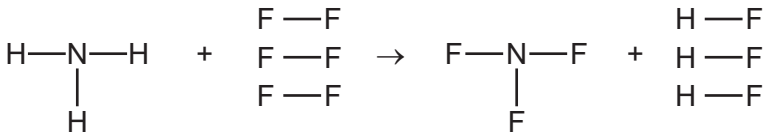
..... [4]

----------**Marking Scheme**----------

bonds broken	energy	
C-H	+412	
C*l*-C*l*	+242	
total energy	+654	[1]

bonds formed	energy	
C-C*l*	–338	
H-C*l*	–431	
total energy	–769	[1]
energy change	–115	[1]
negative sign indicates exothermic		[1]

3 Ammonia is used to make nitrogen trifluoride, NF_3.
Nitrogen trifluoride is essential to the electronics industry. It is made by the following reaction.



Determine if the above reaction is exothermic or endothermic using the following bond energies and by completing the following table. The first line has been done as an example.
Bond energy is the amount of energy, in kJ / mole, needed to break or make one mole of the bond.

bond	bond energy in kJ / mole
N – H	390
F – F	155
N – F	280
H – F	565

bond	energy change / kJ
N – H	(3 × 390) = 1170
F – F	
N – F	
H – F	

.....

..... [4]

second line +3 × 155 = + 465
third line –3 × 280 = (–)840
fourth line –3 × 565 = (–)1695
all **three** correct (2)
two correct (1)

1170 + 465 = 1635
840 + 1695 = 2535
both numerically correct (1)
exothermic reaction with some reasoning (1) [4]

4 **(i)** Complete the following table that describes the bond breaking and forming in the reaction between nitrogen and hydrogen to form ammonia.

bonds	energy change /kJ	exothermic or endothermic
1 mole of N ≡ N broken	+945	.....
3 moles of ..... broken	+1308	.....
6 moles of N – H formed	-2328	.....

[3]

(ii) Explain, using the above data, why the forward reaction is exothermic.

.....

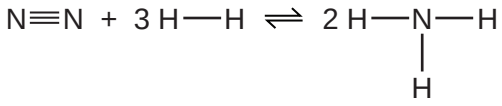
..... [2]

(i) H—H **[1]**
endothermic **[1]**
endothermic **[1]**
exothermic

(ii) More heat given out than taken in **[1]**
–2328 + 945 + 1308 = –75(kJ) **[1]**

OR More heat given out bond forming than taken in bond breaking **[2]**
Must mention bond breaking and forming **[2]**

5 Bond breaking is an endothermic process. Bond energy is the amount of energy needed to break or form one mole of the bond. Complete the table and explain why the forward reaction is exothermic.



bond	bond energy kJ / mol	energy change kJ	exothermic or endothermic
N≡N	944	+944	endothermic
H—H	436	3 × 436 = +1308	
N—H	388		

.....

..... [3]

2328 (ignore + or –) / 6 × 388 (not evaluated); [1]

944 + 1308 / 2252 **and** endothermic and exothermic in table; [1]

2328>2252 or (–) 76 kJ; [1]

or energy of products / RHS > reactants / LHS
or energy needed to break bonds < energy given out on formation of bonds.