READING

READING PASSAGE 1

You *should spend about 20 minutes on Questions 7—76, which are based on Reading Passage 1 below.*

Raining Ice

In May 2012, disaster struck a mountainous region of China's Gansu province. 40 people were killed and 29,300 people evacuated when a brief but extremely violent hailstone storm swept across Min County. Houses collapsed, roads were blocked and crops were destroyed. The extreme weather also affected the power supply and communications in the region. When you consider that hailstones can reach sizeable proportions, the damage they can cause is understandable. The world's largest hailstone was found after a storm in South Dakota and measured 20.5 cm in diameter with a 47 cm circumference - this was after melting caused it to lose 5 cm from its original size. Apart from China and the US, other parts of the world that frequently suffer from hailstorm damage include Russia, India and northern Italy.

Hail is a form of solid precipitation created within cumulonimbus clouds. Cumulonimbus clouds are caused by heating from below and cooling from above. As the earth is heated during the day by the sun, air close to the ground becomes warmer. Hot air is less dense than cold air and therefore lighter so it rises and, as it does so, it becomes cooler. The warm air reaches a cold point called the condensation level where the water vapor condenses and turns back to a liquid form. As the warm air rises to the condensation level, it becomes less able to keep its moisture and condenses into large clouds, which are often called thunderheads. The process of condensation releases heat into the surrounding air making the air rise even faster and release more moisture. These huge clouds are complex systems in their own right, containing large amounts of energy resulting in updrafts and downdrafts - vertical winds that can reach speeds over 176 km per hour and help in the formation of hail.

Hail grows in the thunderhead's main updraft where most of the cloud is

'supercooled' water: water that is still liquid even though its temperature is below o°c. This water will stay in liquid form until it encounters something on which to freeze. There are other particles within the cloud - small frozen raindrops or soft ice particles - called graupel. When the supercooled water hits the graupel, it freezes around it, creating a hailstone. However, this is just the start of the hailstone's journey. A hailstone's eventual size depends upon the intensity of the storm in which it is born. To form a golf ball-sized hailstone requires over ten billion supercooled drops of water and a time span of between five and 10 minutes. This accumulation of additional ice is a process called accretion and takes place in areas of the cloud rich in supercooled water. Accretion takes place in two ways, resulting in two distinguishable kinds of hailstone. In the first process, strong updrafts, which lift the top of the cloud into part of the atmosphere known as the troposphere, take the hailstone through the supercooled layer where it accretes ice, making it heavy enough to fall back through the cloud. On falling, it encounters other strong updrafts, which take it back though the supercooled layer where it grows and falls again. An updraft of 35-55 km per hour will form
small hailstones; hailstones that are 5 cm in diameter require updrafts of 88 kph and hailstones that are 12 cm in diameter need updrafts of 160 kph to grow. The other process involves the hailstone falling slowly through a layer of the cloud rich in supercooled water.

The first process results in hailstones with concentric layers usually alternating between clear and cloudy ice, indicating how it was produced. The opaque layer forms when supercooled water drops freeze quickly onto the growing hailstone and trap tiny air bubbles inside the ice giving it a milky appearance. The next layer - the transparent layer - forms when larger drops of supercooled liquid water hit the hailstone. Here the freezing process is slower, allowing air bubbles to escape and clear ice to form. Hailstones showing little of this layering may have been subject to the second process of formation. Instead of being pushed up through the cumulonimbus by updrafts and pulled back through by gravity several times, these hailstones simply fall slowly through the cloud gathering mass as they drop.

The interior of a cumulonimbus cloud is a place of extreme violence. As the hailstones rise and fall, they collide with each other. The result of this can be their breaking up or the formation of large irregular shaped hailstones. Hailstones are categorised according to their size. The Tornado and Storm Research Organisation classifies hailstorms according to their destructive power, ranging from HO - hard hail composed of hailstones of 5 mm in diameter, which do not cause damage - through H5 storms, destructive enough to damage glass, roofs and injure people, to the most severe - H10 or 'super hailstorms', which cause extensive structural damage and can fatally injure people caught out in the open.

The rate at which they fall varies but can be faster than 160 kph for larger hailstones as they become too heavy for the updraft to support or if a downdraft catches them and blows them violently back to earth. It is estimated that between 40 and 70% of hailstones never reach the earth, melting instead inside the cloud, colliding with and smashing into smaller pieces on their way through the air, or melting in the atmosphere to fall as rain.

Questions 1-8

Do the following statements agree with the information given in Reading Passage 1?
Write

TRUE	*if the statement agrees with the information*
FALSE	*if the statement contradicts the information*
NOT GIVEN	*if there is no information on this*

1 Hailstone storms last a long time and cause considerable damage.

2 The world's largest hailstone had lost volume before it was found,

3 Cumulonimbus clouds hold significant quantities of energy.

4 Cumulonimbus clouds are called 'thunderheads' because they are the cause of thunder and lightening storms.

5 Water always turns to ice when it is under 0°c.

6 A slow freezing rate creates clear ice.

7 Hailstones are classified according to their destructive power.

8 Many hailstones stay within the cloud and do not reach the ground.

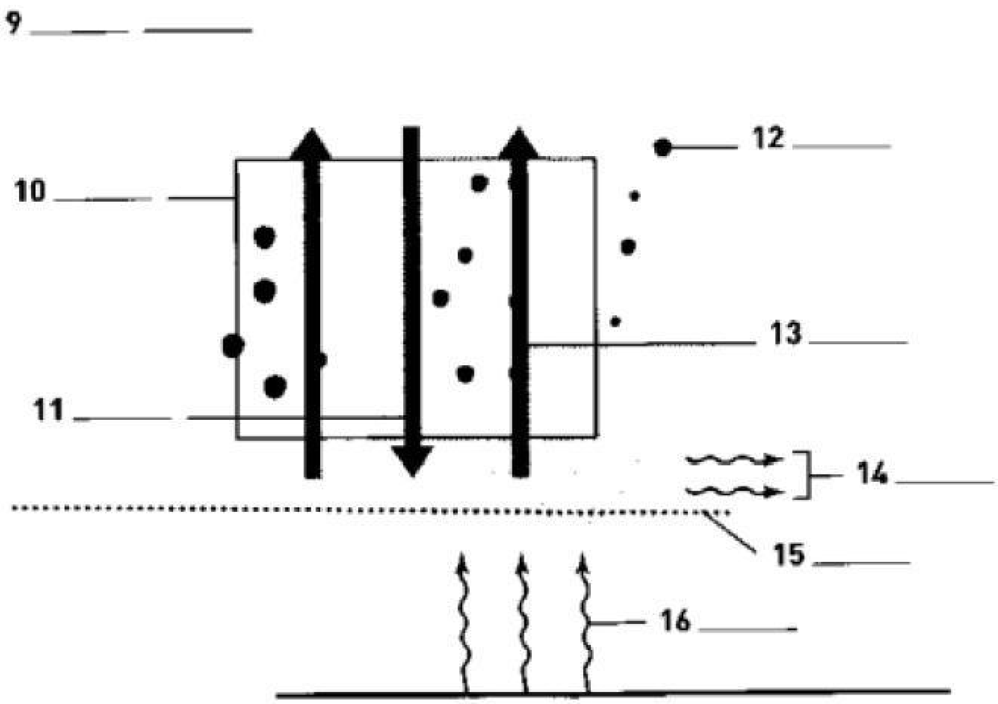
Questions 9-16

Label the diagram below using words from the box.

Write the correct letter, A-H, in spaces 9-16.

A graupel
B updraft
C condensation level
D accretion
E heat released into atmosphere
F downdraft
G warm air
H supercooled area

The formation of hailstones in a cloud



READING PASSAGE 2

You should spend about 20 minutes on Questions 17-27, which are based on Reading Passage 2 below.

Twisted Light

A Why is your mobile phone or wireless signal so slow? If you ask your service provider, they'll tell you that it's the bandwidth. We're running out of signal space on the wireless spectrum. All wireless communications travel through radio or optical frequencies: your TV or radio programmes, your GPS device that helps you find your way, your mobile and smartphone, laptop and wirelessly connected PC. The demands from users and industry on a limited resource, the wireless spectrum, are growing daily and are closely regulated. The reason is that two users cannot use the same signal: think about radio stations, which have to operate on different frequencies otherwise they cause interference with each other. Likewise mobile phone operators cannot transit over the same frequency in the same market at the same time. Government-controlled agencies grant licences to use the wireless spectrum but if a wireless company wants to add more spectrum to its service to boost its capacity, it's likely to be disappointed as there isn't much more available. What is needed is a way of pushing more data through the same amount of bandwidth.

B Now scientists may have found a way of manipulating light waves to carry more information: potentially enough for users to be able to download a film onto a smartphone in a single second. By twisting light waves, scientists could possibly transmit data at speeds of 2.56 terrabits per second: that's 85,000 times faster than the 30 megabits per second currently possible. To put it another way, this is the same as transmitting 70 DVDs through the air in about a second. Researchers based in America, China, Israel and Pakistan have built on previous research from Sweden, which negates the need for more bandwidth by making better use of the spectrum. The basis of the research is to manipulate the properties of light.

C One property of light is wavelength: lasers, radio waves, microwaves are simply different wavelengths of light. Light is made up of photons and photons have two other properties that define a beam of light: spin angular momentum and orbital angular momentum. A good way of thinking about how photons travel is to think of the orbit of a planet: it spins around on its axis (spin angular momentum), and at the same time the planet is also revolving around the sun (orbital angular momentum). The latter force means that light can be twisted around its axis of travel to take the shape of a spiral or a corkscrew. At the centre of the spiral the light waves cancel each other out, leaving darkness in the middle, called an optical vortex. When light travels, it is formed into a spiral shape and it can be manipulated. There are infinite possibilities for ways in which the photon can be made to spiral: clockwise, counterclockwise, tight spirals or loose ones. Each of these spiral states can be uniquely identified but, more importantly for wireless communication, the spirals can be wrapped up within each other - or multiplexed - into a single beam. The beam can be transmitted and unwound at the receiving end to get the data streams back out again, essentially doubling or trebling or even quadrupling the bandwidth.

D. Scientists have been twisting light since the 1970s, and the spin angular momentum of waves is already manipulated in standard wireless communication. For years, Bo Thide of the Swedish Institute of Space Physics theorised that the orbital angular momentum could be used to create the spiral signal or as Thide calls it a 'radio vortex'. Then in an experiment in Venice, his team transmitted two signals simultaneously on the same frequency over a distance of 442 metres. Following on from this, researchers in America, China, Israel and Pakistan, led by Alan Wilner, twisted together eight light data streams, each stream with its own level of orbital angular momentum twist. One of the streams was transmitted as a thin stream while the others were transmitted around the outside, The data beam was then sent to a receiver and untwisted to recover the data.

E The achievement is very exciting for developers of wireless network technology as the useful spectrum of frequencies is largely used up. The orbital angular momentum model would allow for an infinite number of data transmissons without taking up any more of the spectrum. There is a problem, however: researchers can only transmit the data stream one metre, which is an insignificant distance for communication purposes. The short transmission range is due to turbulence in the atmosphere, which disrupts the signal as the light hits air molecules. But the scientists are planning to be able to send the beam considerably further. One idea is to create links every kilometre to extend the network. Another is to build high-speed satellite communication links where the atmospheric problems would not affect the signal. Another possibility is to adapt the technology for fibre-optic use, the way data is currently transmitted over the Internet. Unfortunately, at this point standard fibre-optic cables are not capable of carrying multichannel signals and fibre-optic cables that can carry the signal experience problems of interference between channels as they carry data with high bit-rates,

F Nevertheless, exploiting the orbital angular momentum gives scientists options that could lead to significant increases in data transfer; even a modest increase in the existing data transfer rate is worthwhile. Furthermore, very often technology is pulled along by innovative research so a novel solution to carrying the data-rich signal may not be far behind.

Questions 17-22

Reading Passage 2 has six paragraphs, A-F.

Which paragraphs contain the following information?

Write *the correct letter, A-F, next to Questions 17-22.*

17 changing light waves to increase capacity

18 a practical demonstration of the new technology

19 use of the wireless spectrum needing to be monitored closely

20 overcoming the problem of the short range of the new signal

21 improvements in data transmission possibly leading to technological breakthroughs

22 the prospect of saving people a lot of time

Questions 23-27

Complete the summary using the list of words, A-I, below.

Write the correct letter, A-I, in spaces 23-27.

Researchers are looking for a way of using the **23** __________ more efficiently. One option is to transmit signals that are twisted into **24** __________, and wrapping them together, or **25** __________ them. This is still problematic on earth due to **26** __________ but scientists hope that **27** __________ cable technology will catch up with the research breakthrough.

A	bandwidth
B	atmospheric interference
C	fibre-optic
D	light waves
E	multiplexing
F	wireless spectrum
G	spirals
H	data streams
I	novel

READING PASSAGE 3

You should spend about 20 minutes on Questions 28-40, which are based on Reading Passage 3 below.

Sinking Cities

Looking across the Bund towards Pudong across the Huangpu River in Shanghai, you will see an array of modern worldbeating skyscrapers. In contrast, behind you are the magnificent buildings from the nineteenth century, standing on the high tourist promenade that runs the length of the waterfront, you may also notice that the level of the river is quite a bit higher than that of the buildings on the Bund. It isn't because the river has risen higher than usual due to rainfall; no - Shanghai is sinking. It is an unfortunate problem that Shanghai shares with several other major financial and industrial centres and it is caused by factors most of the cities have in common. Included in the list are New York, Bangkok, Houston and Mexico City, all either built on shaky foundations or low-lying land that is now threatened by rising sea levels.

New York and Bangkok are victims of bad luck. The effect of global warming on the sea levels means that these cities may drown in the oceans that brought them such importance and prosperity. Scientists believe that sea levels in the New York area are expected to rise about twice as quickly as In the rest of the world. The position of the city - situated next to a river, the Chao Phraya, the city is about 50 kilometres north of the Gulf of Thailand. The city is likely to face increasingly severe tropical storms crossing from the Bay as well as threats from coastal erosion and shifting clay soil. It seems unlikely that Bangkok will save itself from drowning under the waters of the Pacific, which are predicted to rise by between 19 and 29 cm by 2050.

Other cities are sinking due to bad planning rather than bad luck. The fourth largest city in America is Houston but it has been built on shaky foundations - and these are now giving way. Houston was literally built on a foundation of sand up to several kilometres deep and loosely packed clay from river deposits formed from the erosion of the Rocky Mountains. In addition to poor foundation materials, Houston has an estimated 300 fault lines running through it. Using GPS data from 24 measuring points throughout the country between 1995 to 2005 a research team were able to monitor the area of subsidence and found an area of Houston measuring 30 kilometres squared was sinking very fast - up to 5 centimetres per year. The reason for the where the Hudson River flows into the Atlantic Ocean - already puts America's most densely populated city at a higher risk of flooding. But the impact of tropical storms and rising tides poses more dangers than just flooding. Beaches in the area will be swept away followed by the surrounding wetlands eventually becoming part of the sea; surrounding river estuaries will see an increase in the salt levels in the fresh water. All of this will affect the ecosystems in New York's immediate area and damage developments along the coast. Bangkok too will fall victim to rising sea levels. Also situated on swamplands

subsidence is quite straightforward: the withdrawal of water from deep beneath the surface. Areas of Houston where water extraction has been stopped have stopped sinking. Similarly, parts of Mexico City are subsiding rapidly due to poor foundations - some areas of the city are sinking up to 20 centimetres a year. The city is built on a dry lake bed in the valley of Mexico, and the council has condemned fifty structures since 2006 because of leaning, and approximately 5,000 homes and buildings are unstable. Some of the heaviest buildings, like the Palace of Fine Arts, have sunk more than three metres over the past one hundred

years and its original ground floor is now the basement. Again the reason is the depletion of the water reserve lying under the city. But in this case there is a complicating factor: a vast complex of drains was built under the city to protect it from flooding by water running from the surrounding mountains. As the city sinks, so do the drains and the wastewater they were supposed to carry away is finding its way back to the city. And it's not only water mains and drains that have been affected; as the city sinks the subway network is subsiding with it.

Back in Shanghai, the same problem is causing the city of 13 million people and ultra-modern skyline to sink beneath the waterline of the Huang Pu River. Originally a small fishing village built on swamplands surrounding

the mouth of the Yangtze River, Shanghai's population has swollen to around 13 million people. The expansion has been sustained by taking water from wells drilled into the aquifer under the city and by constructing massive skyscrapers. According to China Central Television, Shanghai has sunk up to three metres since the early 1990s mainly due to depletion of underground water but also because of the weight of high-rise buildings situated on areas with soft soil. As a partial solution to the problem, Shanghai is trying to reverse the sinking by pumping 5.2 billion gallons of water a year into the water table with some success - so far the city has risen by almost 11.5 cm.

Questions 28-35

Complete the table below.

Choose NO MORE THAN THREE WORDS from the passage for each answer.

Write your answers in spaces 28-35.

City	Situated	Cause of sinking	Effect
New York	where the Hudson meets the Atlantic	the effect of 28.................. and rising tides	increased chance of 29......................
Bangkok	on swamps near the Gulf of Thailand	increasingly damaging storms, 30.............................. and moving soil	a rise in the level of the Pacific of up to 31......................... by 2050
Mexico City	on a 32....................... that has dried out	using up the 33.................................... beneath the city	wastewater drains and subway affected
Shanghai	on wetlands around the 34.....................of the Yangtze River	wells drilled into aquifer and building 35...................	sunk up to 3 metres

Questions 36-40

Choose the correct letter, A, B, C or D.

36 The thing that may strike you when you are standing on Shanghai's tourist promenade is

A the contrasting styles of the buildings.

B its height.

C that the river is higher than the buildings behind the promenade.

D that it runs the length of the waterfront.

37 Which of the following is NOT a predicted effect on New York?

A wetlands becoming part of the ocean

B beaches being lost

C developments along the coastline

D the increasing saltiness of river mouths

38 Houston has been built on

A shallow sand.

B material from the Rocky Mountains.

C volcanic fault lines.

D accurate GPS measurements.

39 The sinking in Houston

A affects the whole city equally.

B is due to water use and the weight of the buildings.

C has completely stopped.

D was measured using historical data.

40 Which of the following is NOT true of Mexico City's drains?

A They were built to defend the city from flooding.

B They run back to the surrounding mountains.

C They are sinking with the city.

D They are carrying wastewater back to the city instead of away from it.