1 次の英文は，「ゲーム理論」について書かれたものの一節である。これを読んで以下の設問に答えなさい。

Game theory is concerned with the actions of decision makers who are conscious that their actions affect each other. When the only two publishers in a city choose prices for their newspapers, aware that their sales are determined jointly, they are players in a game with each other. They are not in a game with the readers who buy the newspapers, because each reader ignores his or her effect on the publisher. Game theory is not useful when decisions are made that ignore the reactions of others or treat them as impersonal market forces.

The essential elements of a game are players, actions, payoffs, and information — PAPI, for short. These are collectively known as the rules of the game, and the modeller's objective is to describe a situation in terms of the rules of a game so as to explain what will happen in that situation. Trying to maximize their payoffs, the players will devise plans known as strategies that pick actions depending on the information that has arrived at each moment. The combination of strategies chosen by each player is known as the equilibrium. (A) Given an equilibrium, the modeller can see what actions come out of the conjunction of all the player's plans, and this tells him the outcome of the game.

Predicting what happens consists of selecting one or more strategy combination as being the most rational behavior by the players acting to maximize their payoffs. An equilibrium is a strategy combination consisting of a best strategy for each of the players in the game.

To illustrate equilibrium concepts, we will use simple games, such as the Prisoner's Dilemma. In the Prisoner's Dilemma, two prisoners, Messrs Row and Column, are being interrogated separately. If both confess, each is sentenced to eight years in prison; if both deny their involvement, each is sentenced to one year. If just one confesses, he is released but the other prisoner is sentenced to ten years. The Prisoner's Dilemma is an example of a 2-by-2 game, because each of the two players — Row and Column — has two possible actions in his action set: *Confess* and *Deny*. The following table gives the payoffs.

Table The Prisoner's Dilemma

		Column	
		Deny	*Confess*
Row	*Deny*	(−1, −1) →	(−10, 0)
		↓	↓
	Confess	(0, −10) →	(−8, −8)

Payoffs to: (Row, Column)
The arrows represent a player's preference between actions.

Each player has a dominant strategy. Consider Row. Row does not know which action Column is choosing, but if Column chooses *Deny*, Row faces a *Deny* payoff of −1 and a *Confess* payoff of 0, whereas if Column chooses *Confess*, Row faces a *Deny* payoff of −10 and a *Confess* payoff of −8. In either case Row does better with *Confess*. Since the game is symmetric, Column's incentives are the same. The dominant strategy equilibrium is [(B, C)], and the equilibrium payoffs are [(D, E)], which is worse for both players than (−1, −1). Sixteen, in fact, is the greatest possible combined total of years in prison.

The game seems perverse and unrealistic to many people who have never encountered it before. If the outcome does not seem right to you, you should realize that very often the chief usefulness of a model is to induce discomfort. Discomfort is a sign that your model is not what you think it is — that you left out something essential to the result you expected and didn't get. Either your original thought or your model is mistaken; and finding such mistakes is a real if painful benefit of model building. To refuse to accept surprising conclusions is to reject [(F)].

(注)

confess：白状する　　conjunction：結　合　　decision maker：意思決定者
dilemma：ジレンマ，(好まない二者択一を迫られる)板ばさみ
equilibrium：均　衡　　impersonal market forces：非人格的な市場要因
incentive：(…させる)誘因　　induce：誘発する，(…を)帰納する
interrogate：尋問する　　Messrs：Mr.の複数形
modeller：モデル設定者　　payoff：利　得　　perverse：誤っている
strategy：戦　略

◇M13(636—339)

設　問

(1)　以下のア～オで，＿＿＿＿下線が引かれたdecision makersから見た場合に，ゲーム理論を用いた決定を行うのに最も不適切と考えられるものを選んで，記号で答えなさい。

ア．石油産出諸国が石油の年間産出量を決定する
イ．自動車会社がある鉄鋼会社から鉄の購入を行うかどうかを決定する
ウ．各国が環境削減の基準について決定する
エ．ある国の空軍がパイロットを雇うべきかどうかを決定する
オ．政党が連立政権に参加するかどうかを決定する

(2)　下線部(A)のequilibriumの概念を35字以内の日本語で説明しなさい。

(3)　文中の(B，C)のBおよびCに入る用語として，*Deny* あるいは *Confess* のどちらかを，それぞれ解答欄に記入しなさい。
(B, C) のBはRowの戦略を，CはColumnの戦略を表す。

(4)　文中の(D，E)のDおよびEに入る適当な数字を，それぞれ解答欄に記入しなさい。

(5)　(F)に入る単語として最も適当なものを，次のア～オの中から選んで，記号で答えなさい。

ア．calculation
イ．logic
ウ．discomfort
エ．reality
オ．dilemma

2 次の英文はコーヒー栽培について書かれた評論の一部である。これを読んで以下の設問に答えなさい。

African honeybees colonized western Panama in 1985, where they naturalized. By 1997 they had become major pollinators of coffee growing near forests at 1,500 m above sea level. Yields of Coffea arabica may therefore be higher near forest, which provides a good pollinator habitat. (A) In a study of 2-year-old plants in Panama in 2001, I observed that flowers were visited not only by native pollinators, but also by the naturalized honeybees.

(B) Ripe berries resulting from open pollination of coffee flowers were heavier than those on control branches that had been bagged with fine-mesh material (from which pollinators were excluded), and were more abundant per flower (49% increase). The open-pollinated fruit was, on average, 7% heavier, whereas a 25% increase in mass was recorded when African honeybees had exclusively dominated the flowers. This suggests that the contributions to final berry weight and total yield may differ for non-native honeybees and other, natural pollinators; however, bees consistently controlled over 36% of the total production.

Do bees control coffee harvests on a larger scale? Long-term data indicate that they do, although the results require detailed analysis. Almost 11 million hectares of coffee were harvested in 2001. Cultivated areas of coffee in Ivory Coast, Ghana, Kenya, Cameroon and Indonesia have increased two- to five-fold in the past 41 years, although yields have decreased by 20-50%. El Salvador and Haiti, like other countries with intensive land usage and little natural habitat, show (C) similar trends. Pollinator loss is implicated in this decline, as sustained and aggressive cultivation may harm pollinators by removing their habitat.

A substantial increase in Latin American coffee yield (kg/hectare) partly coincided with the establishment of African honeybees in those countries, although there was no such change in the Old World, where honeybees originated. This comparison underlines a possible cause-and-effect relationship

between the presence of social bees and coffee yield.

Recent saturation of the neotropics with feral honeybees, which compete with other flower visitors, has caused intensive exploitation of coffee and other flowering plants and has promoted pollination stability. However, although the island of New Guinea has no honeybees, its yields remain high, partly because its native solitary bees pollinate the obligately outcrossing coffee plant Coffea canephora there. Canephora is grown in tropical lowlands and extensively in the Old World, but it is also wind-pollinated.

Declining yields can be offset by expanded cultivation or by increasing planting density, but such remedies are unstable. Although shade conditions significantly improve the flavour of commercial coffee, coffee monocultures often lead to the removal of shade trees. The trend towards cultivating 'sun coffee' (D) at high densities to boost yield will eliminate sites for bee nesting and mask the erosion of pollinator populations, which is shown here to affect yield by 36%. Optimization of coffee harvests and agricultural flexibility in tropical countries in the long term will depend on a consideration of pollinator sustainability and habitat.

(注)

aggressive：積極的な　　boost：ふやす

Coffea arabica, Coffea canephora：コーヒーの種類　　coincide：一致する

erosion：浸食　　exploitation：開拓　　feral：自然の　　habitat：生息環境

hectare：ヘクタール(面積の単位)　　honeybee：ミツバチ

intensive：集約的な　　offset：埋め合わせる　　outcrossing：異系交配

pollinator：授粉を媒介するもの　　remedy：矯正手段　　saturation：飽和

solitary：群居しない　　sustain：維持する

設　問

(1)　下線部(A)の調査から筆者が見出したことは何か，日本語 80 字以内で具体的に説明しなさい。

(2)　下線部(B)はどのような比較を行ったのか，日本語 30 字以内で説明しなさい。また，その比較の結果を日本語 60 字以内で簡潔に説明しなさい。

(3)　下線部(C)の示す内容を日本語 50 字以内で簡潔に説明しなさい。

(4)　下線部(D) 'sun coffee' とは何か，日本語 50 字以内で簡潔に説明しなさい。

3 次の英文はゲーデル(Gödel, Kurt)の不完全性定理とその物理学への影響について書かれたものの一部である。これを読んで以下の設問に答えなさい。

In 1930, the Austrian-born logician Kurt Gödel stunned the mathematical world with the publication of his incompleteness theorem. It applied to formal systems — sets of assumptions and the statements that can be deduced from those assumptions by the rules of logic. For example, the Greeks developed their geometry using a few axioms, such as the idea that there is only one straight line through any pair of points. It seemed that a clever enough mathematician could prove any theorem true or false by reasoning from axioms.

But Gödel proved that, for most sets of axioms, there are true theorems that cannot be deduced. In other words, most mathematical truths can never be proved.

This bombshell could easily have sent shock waves far beyond mathematics. (A) Physics, after all, is couched in the language of maths, so Gödel's theorem might seem to imply that it is impossible to write down a complete mathematical description of the Universe from which all physical truths can be deduced. Physicists have largely ignored Gödel's result, however. "The main reason was that the result was so abstract it did not appear to connect directly with physics," says Cahill.

But then, in the 1980s, Gregory Chaitin extended Gödel's work, and made a suggestive analogy. He called Gödel's unprovable truths random truths. What does that mean? Mathematicians define a random number as one that is incompressible. In other words, it cannot be generated by an algorithm — a set of instructions or rules such as a computer program — that is shorter than the number. Chaitin defined random truths as ones that cannot be derived from the axioms of a given formal system. A random truth has no explanation, it just is.

Chaitin showed that (B) a vast ocean of such truths surrounds the island of provable theorems. Any one of them might be stumbled on by accident — an

equation might be accidentally discovered to have some property that cannot be derived from the axioms — but none of them can be proved. The chilling conclusion is that randomness is at the very heart of pure mathematics.

To prove his theorem, Gödel had concocted a statement that asserted that it was not itself provable. So Gödel's and Chaitin's results apply to any formal system that is powerful enough to make statements about itself.

"This is where physics comes in," says Cahill. "The Universe is rich enough to be self-referencing — for instance, I'm aware of myself." This suggests that most of the everyday truths of physical reality, like most mathematical truths, have no explanation. According to Cahill and Klinger, that must be because reality is based on [(C)]. They believe [(D)] is more fundamental than physical objects.

(人名注)

Cahill, Reginald：オーストラリアの物理学者

Chaitin, Gregory：米国の数学者

Gödel, Kurt：オーストリアの数学者

Klinger, Christopher：オーストラリアの物理学者

(注)

analogy：類　推

assert：断言する

axiom：公　理

bombshell：爆　弾

chilling：ぞっとするような

concoct：作り上げる

couch：表現する

deduce：演繹する

incompleteness theorem：不完全性定理

incompressible：圧縮できない

stumble：つまずく

stun：ぼう然とさせる

設　問

(1)　下線部(A)を和訳しなさい。

(2)　下線部(B)の具体的な内容を 50 字以内の日本語で説明しなさい。

(3)　(C)と(D)には同じ語が入る。最も適当なものを以下から 1 つ選び，番号で答えなさい。

① reason
② abstraction
③ unprovability
④ self-reference
⑤ randomness

(4)　ゲーデルの不完全性定理が物理学的な事象にも関連があることを示す例として，本文であげられている内容を 80 字以内の日本語で説明しなさい。

4 次の英文は海とプランクトンについて書かれた文章の一部である。これを読んで以下の設問に答えなさい。

The average depth of the oceans is about three miles, but there are places where the water is seven miles deep. So the deepest oceans are deeper than the tallest mountains are high. (A) Prophets have predicted that the oceans will, one day, provide us with most of our food. Simple mathematics will show that this is not really feasible. We presently take only 3–5% of our food from the seas, and even if we were to double that in the next decade, our food problems would not be solved. This is because with the world's population increasing at its present rate, doubling the produce from the sea would add only 3–5% more to a population that has increased over 18%. Superimposed on this is the complication that (B) the deep oceans are just like deserts and are not very productive. In fact many parts of oceans are almost completely devoid of life.

Where currents are deflected upward by the mountains on the ocean floor, cold water from the ocean depths wells up to the warmer surface. This cold water carries with it tonnes of accumulated sediment from the floor. The sediment is natural fertilizer and promotes the bloom of life in the surface layers of the oceans. Chlorophyll-bearing plankton, (C) phytoplankton, have an easy life at such times. These primitive plants simply drift in the light-filled, warm, nutrient-rich oceanic soup and spend their time photosynthesizing and reproducing. As a result, animal plankton flourish on their ample food supply. These tiny organisms, barely visible without a [(D)], form the basis of the oceans' complex food webs. One liter of sea water may contain 12 million phytoplankton. These food producers, however, can live only near the oceans' surface, since the sunlight needed for their photosynthesis cannot penetrate below about 200 meters.

Not only are phytoplankton essential as food producers, but they also release much of the Earth's oxygen as a waste product of photosynthesis. Thus the

importance of maintaining viable oceans is apparent. All nations recognize the fragility of the food webs in the sea and express their desire to minimize pollution which is the main cause of their destruction. The [(E)] nations, however, often rely on oil to sustain their economy and huge quantities of this fuel are transported by ever-bigger tankers through environmentally sensitive areas.

(注)

accumulate：蓄積する

ample：十分な

chlorophyll：葉緑素

deflect：そらせる

devoid of～：～がない

flourish：繁栄する

food webs：食物連鎖

fragility：こわれやすさ

layer：層

nutrient：栄養分

photosynthesize：光合成を行う

prophet：予想する人，予言者

sediment：沈殿物

superimpose：重ねる

tonnes of：大量の

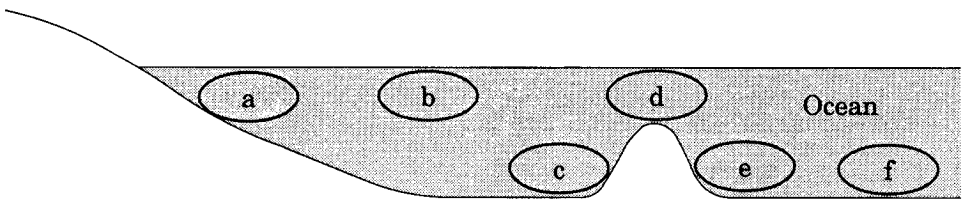
viable：生存可能な

設　問

(1)　下線部(A)を和訳しなさい。

(2)　下線部(B)は，どのような理由によるのか。本文の内容に沿って 100 字以内の日本語で具体的に説明しなさい。

(3)　本文中では，下線部(C)の生物フィトプランクトンの繁殖に適しているのはどのような場所と述べられているか。下に模式的に示す海の断面図中 a — f のうちで最もよくあてはまる場所を選び，さらに 80 字以内の日本語で具体的に説明しなさい。



(4)　(D)，(E)には 10 文字および 4 文字の単語がそれぞれ 1 語ずつ入る。これらを答えなさい。

(5)　フィトプランクトンが果たす生物学的な役割にはどのようなものがあるか。本文の内容に沿って日本語で簡潔に 2 つ述べなさい。