```
#include <iostream>
#include <string>

using namespace std;

typedef struct coup {
  int pos; // 0..20 => 21 allumettes
  int nb;  // 1..3
};

typedef struct position {
  int damier [21]; // 0..20
  int player;      // 0 => ordi, 1 => humain
};

position initiale() {
  position p;

  srand(time(0));
  for (int i=0; i<=20; i++) p.damier[i] = rand() % 2;;

  p.player = rand() % 2 ;
  return p;
}

/* Exercice 1 */
bool coup_possible(position p, coup c) {
  if ( (c.pos < 0) or (c.pos > 20) or (p.damier[c.pos] == 0)) return false;
  if (c.nb == 1) return true;
  c.pos++; c.nb--;
  return coup_possible(p,c);
}

/* Exercice 2 */
position mouvement (position p, coup c) {
  p.damier[c.pos] = 0;
  if (c.nb == 1) { p.player = int(not(bool(p.player))); return p; }

  c.pos++; c.nb--;
  return mouvement(p,c);
}

/* Exercice 3 */
coup entrer_coup (position p) {
  coup c;
  cout << "Position (0..20) : " ;
  cin  >> c.pos ;
  cout << "Quantité (1..3) : " ;
  cin  >> c.nb ;
  if (coup_possible(p,c)) return c;
  else return entrer_coup(p);
}


/* Exercice 4 */

/*
bool terminale (position p) {
  int i = 0;
  while ((i<=20) && (p.damier[i]==0)) i++;
  return (i>20);
}
*/

bool terminale (position p, int g, int d) {
  if (g>d) return true;
  if (p.damier[g]==1) return false;
  return terminale(p,g+1,d);
}

bool terminale (position p) {
  return terminale(p,0,20);
}
```

```
/* Exercice 5 */
bool gagnante (position p) {  // gagnante pour p.player
  coup c;
  position p1;

  if (terminale(p)) return true;

  for (c.pos=0; c.pos<=20; c.pos++)
    for (c.nb=1; c.nb<=3; c.nb++)

      if (coup_possible(p,c)) {
        p1 = mouvement(p,c);
        if (not gagnante(p1)) return true;
      }

  return false;
}


coup ordi_malin (position p) {
  coup c,c1;
  position p1;

  for (c.pos=0; c.pos<=20; c.pos++)
    for (c.nb=1; c.nb<=3; c.nb++)

      if (coup_possible(p,c)) {
        c1 = c;
        p1 = mouvement(p,c);
        if (not gagnante(p1)) return c1;
      }

  return c1; // renvoi un coup possible
}


void affiche(position p) {
  for (int i=0; i<=20; i++)  printf("+−−");                 printf("+\n");
  for (int i=0; i<=20; i++)  printf("|%2d",i);              printf("|\n");
  for (int i=0; i<=20; i++)  printf("+−−");                 printf("+\n");
  for (int i=0; i<=20; i++)  printf("|%2d",p.damier[i]);    printf("|\n");
  for (int i=0; i<=20; i++)  printf("+−−");                 printf("+\n");
  cout << "Player : " << p.player << endl ;
};


/* Exercice 6 */
void boucle_jeu(position p){
  coup c;

  affiche(p);
  if (terminale(p)) { cout << "The winner is Player " << p.player <<endl ; return; }

  if ((p.player==1) && (!gagnante(p)))
      cout << "Désolé mais tu n'as plus aucune chance de gagner!!!" <<endl ;

  if (p.player == 1) c=entrer_coup(p); else c=ordi_malin(p);
  p = mouvement(p,c);
  boucle_jeu(p);
}


int main () {
  position p = initiale();
  boucle_jeu(p);
}
```